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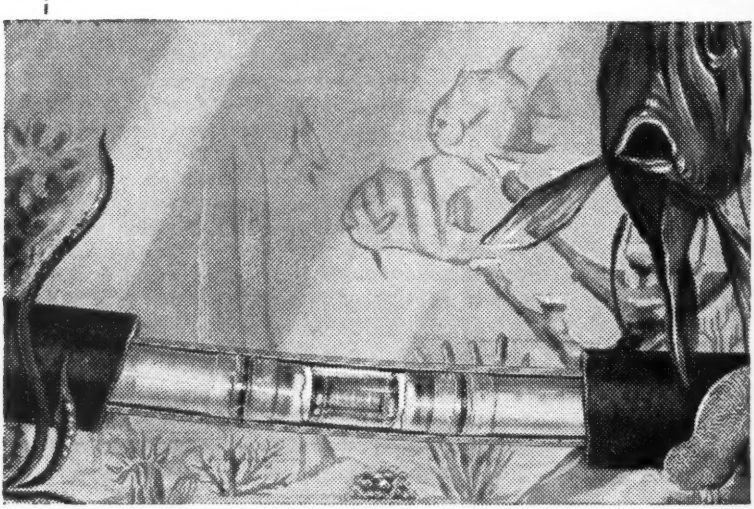

Cutaway view of deep-sea amplifier. Elements are housed in plastic cases, enclosed in steel rings in a copper tube. Glass tape, armor wire and impregnated fiber complete the sheath.

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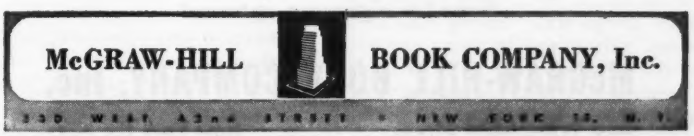

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10

The Engineering Shortage Continues*

By S. C. HOLLISTER

Dean, College of Engineering, Cornell University
President ASEE

Last autumn a survey was made by the Manpower Committee of the Society to ascertain the outlook for engineering graduates in the immediate future. The result was that the freshman class was found to be substantially below that of 1949—a drop of about twenty per cent.

During the winter, much publicity was given to the shortage and its consequences upon the welfare and security of the nation. Special attention was given to informing high school principals and counselors concerning the great need for engineers. It was noted that instead of a pre-war rate of 5.8 per cent of male high school graduates who entered engineering schools, only 4.8 per cent elected this profession in 1950. Many hoped that the effort to inform secondary school officials of the situation would result in a larger freshman class in the fall of 1951.

As of June 1, 1951, the Manpower Committee made a survey of the 34 colleges that had participated in last fall's survey, to obtain the best estimate of the size of the freshman class of this coming fall. The result of this survey indicated that the expected class would be of the same size as that of last fall. Thus it appears that during the last year there has been no appreciable increase in the percentage of high school graduates desirous of entering the study of engineering.

There is little doubt that a variety of factors are responsible for the sustained low rate of students entering upon engineering. Before the outbreak of war in Korea, there was a much-published and mistaken anticipation that there would be a great over-supply of engineers; and to some extent this notion still lingers. In some quarters high school guidance counselors are reluctant to advise a boy to take an engineering course when there is only one chance in two that he may graduate (not realizing, no doubt, that the same ratio applies to collegiate work as a whole). Interesting careers for boys with similar aptitudes are developing in other fields. The generalization of high school training may not provide the necessary entrance requirements for engineering unless the choice is made early; and some boys do not reach a decision soon enough. These factors, and no doubt others, tend to restrict the number that may enter engineering from high school. The writer believes that any substantial increase in the number so entering will be slow in maturing; but also that it is essential to work diligently toward achieving this end.

Need for Engineering Graduates

About a year ago the writer was brash enough to make an estimate of the annual need for engineering graduates, and placed the figure at 30,000. The Bureau of Labor Statistics had previously estimated the need through the 1950's as gradually rising from 18,000 to 22,000 over that period. This agreed with the pre-war trend of engineering graduates given in the writer's paper in this JOURNAL in March 1949. Allowing for 10,000 needed by the armed force as engineering specialists, estimated from the Report, for a 3½ million man military

* Presented before the ECAC, at East Lansing, June 1951.

force, gave an average total over the period of 30,000. This did not, of course, make any provision for utilizing engineers in positions in which no engineering training is required. At the time, some thought, and time proved, that this was far too conservative a figure.

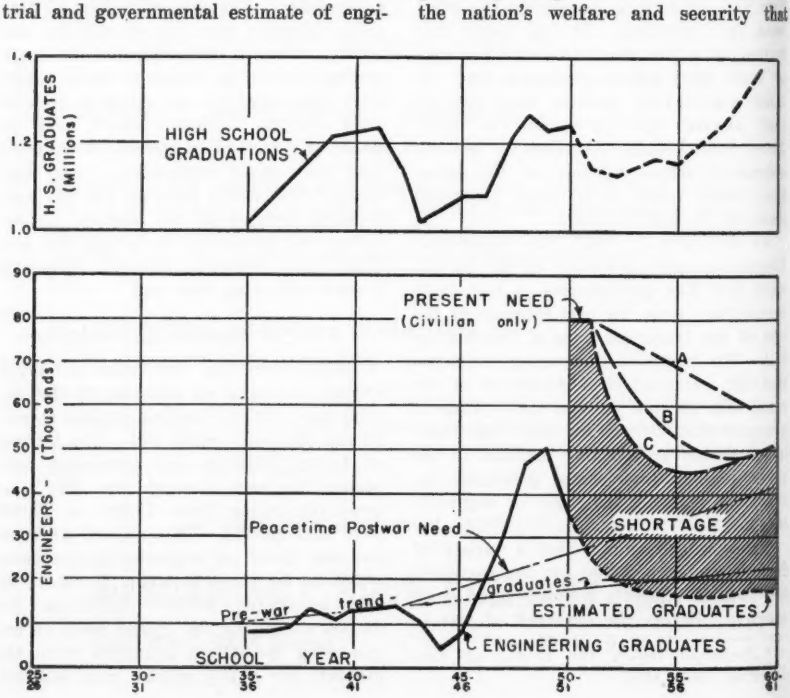
Early in June 1951 the Engineering Manpower Commission made a survey of 378 companies and government agencies, to determine their immediate need of engineers. The result of this survey indicated a total national need of 80,000 engineers, quite independent of those needed in uniform. Against this need there were graduated 38,000 men, half of whom, the Manpower Commission determined by survey, were committed or subject to military duty. The unfilled demand as estimated by industry was therefore 60,000 by the end of June.

Some persons believe that the industrial and governmental estimate of engineers needed is too high; that it is not a shake-down figure of real need. I can only say to this that many industries expressly stated their estimate was not inflated and that it was realistic. The fact is, furthermore, that there is no other dependable figure available, and no way to get one except by the method employed in obtaining this one. Even if one discounted the total figure by 25 per cent, or 20,000, there is still no comfort in the resulting unfilled shortage of 40,000.

Significance of Statistical Evidence

What is the outlook? What is the important significance of these figures?

There is great risk in attempting to forecast the situation respecting manpower over the next few years; yet the writer believes the present status of engineering manpower to be so critical in the nation's welfare and security that



every means available should be utilized to make adequate preparation for the future. Appraisal must be made with what evidence is at hand, without awaiting the elusive and practically unattainable perfect data.

The first factor of importance (see chart) is that there is a wholly inadequate supply of engineering graduates to meet the ultraconservative estimate of need of 30,000 per annum. The best efforts at increasing interest of high school graduates may add 4000 or 5000 to the annual graduations in engineering—but not before 1956. With the addition of 5000 that year the total graduations would be only 22,000.

The second factor of importance is that at present enrollments, and with no withdrawals for military service of any engineering students, there will not be enough graduates by and after 1953, at least to 1961, to meet the peacetime need as conservatively estimated by the Bureau of Labor Statistics, the shortage being at least 20 per cent.

The third factor of importance is that during the post-war four years prior to Korea, 149,000 were graduated and employed. This is a greater rate than that of the pre-war years upon which the Bureau of Labor Statistics based its peacetime estimate for the 1950's, by nearly 90 per cent. A conservative estimate of post-war peacetime need would appear to be 30,000.

The fourth factor of significance is that the industrial and governmental *civilian* need of engineers is far greater that the graduating class of 1951 (38,000). Whatever the military requirements for engineers may be, they are not available except by taking men from indutry; thus further intensifying the needs of industry.

The fifth factor of importance is that all considerations of need are based upon the current pattern of utilization of engineers by industry and government. The first step toward bringing need and supply toward better agreement will be to *change the pattern of utilization* through spreading the engineer's work over a greater range, and thereby lessening the need. The extent to which policy decisions by industry and government can in this way achieve a modification will determine the extent of the reduction of need (see curves A, B or C, on chart). In any case, it does not now appear that by any present or likely pattern of utilization or available source of supply the need and supply will be brought into balance over the next decade.

The Engineering Manpower Commission of the EJC: Its Objectives and Activities

By MR. CAREY H. BROWN

Chairman, Engineering Manpower Commission, Engineers' Joint Council

Cooperation of the American Society for Engineering Education with Engineers Joint Council in the formation of the Engineering Manpower Commission is most appropriate and timely. The Commission consists of three representatives of ASEE, Mr. Armsby, Dean Hollister and Dean Saville, and three representatives of each of the constituent societies of Engineers Joint Council, namely, the Mechanical, Civil, Electrical, Chemical, and Mining and Metallurgical Engineers. The Commission's headquarters are located with EJC in the Engineering Societies' Building in New York City. Mr. T. A. Marshall, Jr. is Executive Secretary. Incidentally, it seems to me that the EMC is a very good illustration of the ability of the engineering profession to act in unity when the need arises.

Failure or inability to foresee or to provide for the tremendous industrial and scientific growth of the Country since World War II, the demands of the present defense program and the coincidence of the passing of the G. I. college training program with the arrival at college age of the meager boy crop of the early thirties are main causes of the present shortage of engineers.

A survey in June 1951 (the present month) of the needs of 378 companies and government agencies shows that about 80,000 engineers are needed now exclusive of the needs of the military. When the current graduating class of 38,000 is absorbed there will still be an unfilled demand for 42,000 engineering graduates. However, a recent study of the 1951 class of engineering graduates showed that the military, through R.O.T.C. and reserve programs, and through the Selective Service System, will siphon off about 19,000 engineering graduates. The actual unfilled demand will then be for more than 60,000 engineers.

The urgent need for engineers cannot be met through the current sources of supply. The 1952 graduating class will be only about 26,000; 1953 about 17,000; 1954 probably even less than 1953.

Causes of the Shortage

The increased complexity of our industry and the development of new technological areas such as atomic energy, antibiotics, jet propulsion, electronics, etc. have caused a definite upturn in the use of engineers and scientists quite independent of mobilization. The ratio of engineers to direct labor has been increasing steadily since 1890. It now stands at about 1600 engineers per 100,000 workers according to the Bureau of Labor statistics and there is no sign yet that the relationship has commenced to level off.

The present partial mobilization has caused another sharp increase in the demand for engineers to speed up and improve the design, development, and production of the implements of modern warfare and other essential defense and civilian needs, and for the expansion of existing plants and facilities so vital to the national defense. Superimposed on this, is the loss of technical manpower

in industry as the result of the call of reservists to the service and the demands of Selective Service.

It is not possible to determine from the answers obtained whether the sharp increase in demand is due to the tooling-up needs of a partial mobilization, or because of the extreme technological advance of the past several years and the increased use of engineers and scientists by various organizations and agencies. There is some reason to believe that much of the increase may be a long term trend.

Extent of the Shortage

The Engineering Manpower Commission is deeply concerned over the magnitude of the shortage of engineers and scientists and its probable consequences to the national health, safety, and interest. Studies will continue to be made to determine to what extent the shortage is a short term or a long term problem and what efforts can be made to aid government, private enterprise, and others in determining policies to promote the most effective utilization of engineers and to maintain the supply, so that our technological superiority will not suffer.

The seriousness of the situation is aggravated by the fact that coupled with the existing shortage is the prospect of increasing shortage over at least the next four years. The output from our engineering colleges is fairly well fixed until 1954. The prospect as to numbers of graduates compared to foreseen demand is not encouraging.

Dean Hollister has told me that he expects to undertake at once revised estimates in accordance with the figures presented to you today. In making such an estimate of the needs of future years, it will of course be necessary to formulate some judgment as to the division of this 60,000 present estimate of unfilled need. How many of that number are needed temporarily to meet requirements of defense industry which will not repeat, and how many of that number represent a continuing requirement over coming years as a result of technological development in industry?

The Effect of the Shortage and the Steps to Counteract It

What is the effect of this shortage? The strength of the United Nations in the present world struggle depends upon industrial might. We can not match our enemies in numbers of men—we must excel them in the quality and quantity of weapons produced as well as in the spirit and resourcefulness of individual soldiers. If the United States is to be "The Arsenal of Democracy" we must have the necessary trained technical manpower, both in the Armed Services and in industry. To do this we must keep the pipeline full by steps to meet estimated needs for freshmen and graduates, as indicated on the slides previously shown you. Without student material our facilities for engineering education will suffer, to our great disadvantage.

To meet these problems the EMC of EJC was organized "To Aid in Establishing the Importance of the Engineering Profession to the National Economy, to Aid in Maintaining the Supply of Trained Engineers and to Promote the Most Effective Utilization of Engineers in the National Health, Safety and Interest."

How have we gone about this? The first step was to get wide publicity for the facts—or the best possible estimate of the facts—as to "The Critical Shortage of Engineers." Dean Hollister's article, titled as above, and various other articles on the same or similar subjects have brought about quite widespread realization of the seriousness of the situation. Action taken as to deferment of college students, though not pin-pointed so as to make it apply to the specific needs here discussed, indicates such realization. The pronouncements and charts of the U. S. Bureau of Labor Statistics have been changed so as to present to prospective students an entirely different picture as to the outlook for engineers.

The EMC published and distributed to principals, guidance teachers and science teachers in some 23,000 high schools a circular descriptive of the need and the opportunity for engineers, accompanied by other material relating to the importance of the engineering profession and the opportunities which it offers. We have urged upon the Department of Defense and upon civilian agencies of the government, steps to secure most effective utilization of engineers. Mr. Armsby of the Office of Education of the Federal Security Agency, as a member of EMC, has been very effective in this connection. The Civil Service Commission has taken steps to avoid misuse of engineering manpower. The Defense Department has not yet gone as far as it should in organizating its procedures to "Promote the Most Effective Utilization of Engineers."

The problem is a large one but it *must* be solved, as the most serious aspect of the shortage of engineers and scientists is its effect upon the production of munitions. One serious defect in the present situation is the almost universal tendency of the Armed Services to catalogue every Reservist *now* in the same rating which he had in the Service in Warld War II. If he was an artillery observer then he is so thought of now, even though meanwhile under the G. I. Bill or otherwise, he may have graduated in electrical engineering and have had considerable practical experience in some specialized field. Draftees seem, in many cases, to be assigned with little regard to civilian training and experience.

Without doubt this situation will improve. Steps are now underway to assure to defense industries more adequate opportunity to present their cases for deferment of individuals essential to defense production.

There is a lot of emotional feeling regarding the service of men under arms as compared to their service in defense industry, but we must be realistic and objective with regard to our point of view on that subject. It goes without saying, I believe, that we cannot possibly match our potential enemies in numbers of men. We must out-produce them. For that reason it is absolutely essential, as the previous speakers and others have pointed out and as you no doubt realize, that our manpower be utilized where it is most effective. In some cases that may even be contrary to the inner desire of the man himself; but somehow we must get across the idea that service in production and service under arms are equally important and honorable.

Industry, too, must avoid waste of technical manpower. The institution within industry of well-planned high level training courses for graduate engineers is urged by EMC as a means of securing the integration of these men into productive activity and their ability to make maximum contribution to the National effort. The reestablishment of Federally aided training courses for technicians is under consideration.

The Demand for Engineers

I would like to read from an advertisement which I clipped from a recent issue of a technical journal. This bears upon the general situation as to the need for engineers for both military and civilian objectives. I will omit the name of the company—just call it Blank Company. My only possible objection to this article is use of the words "Qualified" and "Experienced." Perhaps this organization should train its own men.

This is the advertisement as it appeared:

"THE OPEN DOOR

to career opportunities for QUALIFIED ENGINEERS *Career* opportunities for *experienced* ELECTRONIC, ELECTRICAL and MECHANICAL ENGINEERS — PHYSICISTS — METALLURGISTS — CHEMICAL and CERAMIC ENGINEERS are now open at ———, pioneer in many of the world's greatest developments in virtually every field of ——— (the company product).

The opportunities are in research, development, design and application, also in

technical sales—on commercial projects as well as the nation's defense program.

These are not temporary positions. Many of ———'s activities today are designed to satisfy the nation's military needs. ——— however, has always been (even in peacetime years) an arsenal from which the military forces have been equipped with the finest ——— apparatus.

——— also is working on many commercial long-range projects. They call for expanding research and development in a diversified line of products. These openings offer lifelong career opportunities. Unlike feast or famine businesses, ——— has forged ahead regardless of wars or depression.

At ———, you enjoy professional status, recognition for accomplishments . . . unexcelled research facilities for creative work . . . opportunities for advancement in position and income . . . pleasant surroundings in which to work. You and your families participate in Company-paid hospitalization, accident and life insurance. Modern retirement program. Good suburban or country residential and recreational conditions. Opportunities for graduate study.''

I read this to illustrate what opportunities the law of supply and demand is likely to bring forth for engineers in many companies in addition to those which already offer these advantages.

This and other similar advertisements, and a consideration of the new fields which science is opening up to industry lead to the belief that engineering activities are entering upon a vast expansion. Irrespective of the new fields, the increasing population of the country and the high birth rate promise high demand for the products of industry. Admitting that a portion of the present shortage is due to defense demands, there remains a great increasing requirement to meet production for civilian use. Should high production to meet defense needs continue, as seems quite likely, there will be continued demand for more advanced and improved designs to keep the United States always in the forefront as to quality of weapons.

Perhaps I may briefly summarize the whole situation, as we look at it, as follows:

Engineers are essential to the defense effort and to our industrial future.

Engineers are in short supply.

Engineers must be utilized to the maximum possible advantage.

The "Engineering pipeline" must be kept full. Adequate supply of this critical element of America's manpower is essential.

ANNUAL MEETING

June 23–27, 1952

Dartmouth College **Hanover, N.H.**

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
*Allegheny	Carnegie Institute		E. B. Stavely, Pennsylvania State College
Illinois-Indiana	University of Illinois	May 17, 1952	D. G. Ryan, University of Illinois
Kansas-Nebraska	University of Nebraska	Nov. 16–17, 1951	Kenneth Rose, University of Kansas
Michigan	University of Detroit	May 10, 1952	W. P. Godfrey, University of Detroit
Middle Atlantic	Newark College of Engineering	December, 1951	S. J. Tracy, Jr., City College of New York
Missouri	University of Arkansas	April 5 or 12, 1952	R. Z. Williams, Missouri School of Mines
National Capital Area	Capitol Radio Engineering Institute	Oct. 2, 1951	W. Oncken, Jr., Bureau of Ordnance
New England	University of Rhode Island	Oct. 13, 1951	W. C. White, Northeastern University
North Midwest	University of Wisconsin	Oct. 5 & 6, 1951	K. F. Wendt, University of Wisconsin
*Ohio	Ohio State University		W. F. Brown, University of Toledo
*Pacific Northwest	Seattle		T. H. Campbell, University of Washington
*Pacific Southwest	Los Angeles San Francisco	April, 1952	S. F. Duncan, University of Southern California
*Rocky Mountain	University of Wyoming		E. J. Lindahl, University of Wyoming
Southeastern	Clemson College	April 10, 11, 12, 1952.	R. L. Sumwalt, University of South Carolina
Southwestern	University of Houston	April 11 & 12, 1952	H. P. Adams, Oklahoma A. & M. College
Upper New York	Clarkson College	Oct. 5–6, 1951	W. H. Allison, Clarkson College

Members of the Society are welcome at all Section Meetings

* No Date Set.

Present Status of the Problem of Scientific and Engineering Manpower*

By M. H. TRYTTEN

Director, Office of Scientific Personnel, National Academy of Sciences–National Research Council

This is perhaps a particularly appropriate time to review the status of the problem of the supply and utilization of scientific and engineering personnel. This is true because on the one hand the dimensions of the demands for such personnel for all of the various activities involved in the maintenance of our civilization and in national plans for mobilization are beginning to become clearer. It is also possible at this time to review some of the halting attempts to achieve national policy and to forecast the difficulties which lie ahead in solving this most difficult of all of our problems. And finally, it is possible to estimate a little more accurately than heretofore what may be happening to our pipeline of personnel in training.

The demand for engineers this summer is probably the greatest that has ever been known in our history. I need not go into details on this matter, since I believe my colleague, Colonel Brown, will indicate the results of a recent survey by the Engineers Joint Council. Your own experience has been sufficient so that I am sure you will not be unduly astonished at the results of this survey. Let me add merely in passing that the demand in many of the fields of science appears to be of the same order of magnitude in proportion to the personnel in those categories as is the case for engineers.

I need not stop to discuss the probable future supply in the field of engineering, since that situation, too, I believe, is familiar to you. You are aware of the progressively lowered enrollments in the various engineering undergraduate classes and also of the probable magnitude of the freshmen class this fall which, according to the latest information, seems to be likely to be less than the freshmen class of 1950. Here, too, I would only add that the phenomena which gave rise to these lowered enrollments seem to be equally effective in the fields of the sciences so that the graduating classes in the future will also progressively decrease in the sciences much as they are decreasing in the field of engineering.

I am sure you will agree with me that there is no phenomenon at the present time that has more serious implications for the future than this widening divergence between supply and demand for highly trained manpower. There is a very direct relationship between the productivity of any nation in its industrial output and its supply of scientific and engineering personnel. This can be expressed differently by stating that there is a very direct relationship between the standard of living of any country and its supply of scientists and engineers. This has been the basis of a recent thoughtful article appearing in *The American Scientist* the official organ of Sigma Xi, by Ewart Smith, (reference: Vol. 39, p. 274, April 1951). While this is important enough in itself, it is, of

* Given at General Session of American Society for Engineering Education, East Lansing, Michigan, June 28, 1951.

course, overshadowed at the present time by the direct relationship between the number of scientists and engineers in any country and its ability to produce in adequate quantity and to use the most effective military equipment possible in the light of the present development of science. And yet in spite of these close relationships, in spite of the direct dependence of both the national welfare and the national security on the supply of personnel in these categories, the phenomenon itself remains essentially unknown and unappreciated by the general rank and file of persons in the population. I believe it is fair to state that this phenomenon is not even well understood and well appreciated by great numbers of scientists and engineers themselves. I know this to be true because I have spoken to groups of both scientists and engineers about the situation and have always been astonished at the lack of awareness of the problem which is manifest in such a discussion.

Part of the reason for this lack of understanding is the relative recency of the problem, since prior to World War II no such problem was recognized. Part of the reason is that we have been unusually fortunate in that our educational institutions have developed rapidly and spontaneously in response to powerful social movements and without the necessity of Federal funds for any substantial part of their support. There has always been a keen appreciation of the importance of education among our population. Many of our colleges have been founded and maintained by wholly private groups to serve some social or religious end of their own. The public generally has been generous of its support to such institutions and has been willing to sanction the setting aside of substantial portions of local tax monies for the development of education. Usually the motivations behind these impulses have been a genuine interest and desire to see to it that the maximum of opportunity is available so that the young men and women of the nation might realize their potentialities. There was thus flowing from our schools and colleges over the past decades since the turn of the century an ever increasing supply of highly trained young people, which apparently up to World War II was reasonably well adjusted to the increasing needs of our civilization for such highly trained specialists. It is only since World War II and under the stress of a new emergency that the sharp increase in demand and the failing supply have become conspicuous. I would call attention to the fact, however, that throughout most of our history the focus of attention has been on providing educational opportunities for individuals to reach their own maximum potentialities, rather than on the products of the universities and colleges as an essential resource for the necessary activities of our civilization. It is only recently that the compelling importance of personnel with specialized training as an indispensable factor in the national welfare has tended to focus attention on the supply of persons emanating from the schools, rather than on the welfare of the individual. This is a major shift in interest and one which is going to require real effort if it is to be driven home into the consciousness of the average American. It must be understood if the public is to sanction the steps that must be taken to provide an adequate flow of specialized personnel. It will not be easy, because it substitutes an abstract idea for an emotion.

It may be well to mention here, too, that we have been exceedingly fortunate in that the development of higher education in the United States throughout the past five decades has been undisturbed, excepting for two short periods, by substantial interference arising from military activity. During this period most young men have found it possible to progress directly through the various stages of training without having to take out substantial periods of time for military training or service. The effect of this is probably not adequately under-

stood. I can recall, for example, that the development of radar during World War II was largely in the hands of specialists in electronics who had graduated from the engineering schools and physics departments. During the middle of World War II an analysis by the National Roster uncovered the fact that the average age of these young specialists was less than twenty-six. Most of them were, therefore, young men with a bachelor's degree plus one or two years of graduate study prior to their employment, or war work in electronics. I can quite well imagine that had these young men each been required to spend a year or more in military training or service many of them would not have achieved the level of experience which made their employment on these projects possible. Others again could possibly have been deflected from the area of training which they had entered upon, and finally, all of them would have been at least one year less advanced, which at that age is a considerable factor. It would seem to me highly reasonable to suggest that the ultra important radar developments in World War II would at least have been delayed and in many cases might not have succeeded had this been the case.

I should like to suggest that in thinking of the problem of scientific and engineering personnel at the present and the apparent increasing divergence between the supply and demand, that the matter be looked at against a larger background than has perhaps been the case in some presentations in the past. I know that it is customary to blame this divergence largely on a public attitude that the technical professions appeared for a short time to be threatened with overcrowding. While this may well have been an important factor, it seems to me that it is possibly not even the most important factor. It is true that engineering fall enrollments for the past year reduced to the point where actually a smaller percentage of the high school graduates of 1950 entered engineering than was the case prior to World War II. But there may be a number of factors which are important considerations in this connection. One of these is unquestionably the high employment opportunities with substantial salaries for personnel of moderate training. It is, of course, well known that union wages in a number of activities are sufficiently high to be attractive to many high school graduates. But there are other employment opportunities also that apparently offer important inducements. Many of these are activities which require only a reasonably short period of training, such as the many maintenance and services activities in the fields of automotive transport, home appliances of various kinds, including air conditioning, and others. In the fields of advanced training the number and variety of job openings appear to be steadily on the increase in our civilization. In the field of business, for example, there are increasing opportunities for persons with rather highly specialized training, because of the increasing complexity of modern business organizations and the precision with which they must operate. Each one of the larger corporations has a wide variety of positions in which they themselves have established reasonably long training programs or which require individuals with specialized training from universities and colleges. Because of these demands recruitment programs have increased and competition for personnel of high ability has increased.

Since the beginning of the century the population of the United States has only increased by approximately 60%. Yet in many fields the increase in personnel has been vastly greater. In most of the sciences and engineering the increases have been approximately 700%. In such academic fields as modern languages the percentage has actually been greater, up to about 800%. Even in the teaching profession school teachers as a whole have increased by nearly 300%. While there is this vertical rise in the increase in a number of specialities, there has occurred simultaneously a substantial

increase in the number of professions which require comparable long training. But all of these factors together are producing a greater and greater competition for that relatively small percentage of the population which is capable of taking and using advanced training. The factor which suddenly makes this dramatic is the imposition on the normal rate of development of technology in our civilization, a sudden and dramatic increase due to the present remobilization and to the demands produced by the international situation generally. It is not only in the sciences and engineering that there is a tremendous competition for personnel at the present time. Due to the suddenly increased activities of the Federal Government in all of its branches, there is unusual recruitment also for experts in the fields of management, of the social studies, and in other fields.

The increasing demand is, however, matched by what appears to be a decreasing proportion of individuals from the high schools who elect to enter the fields of science and engineering. While this may be due to the increasing opportunities in other fields, it seems probable that it may be affected also by other factors. One of these may be the effect of changing emphasis in education at the secondary level. There has been a steady mounting interest on training the high school population for the so-called activities of life and for citizenship. It is true that a large proportion of high school graduates do not go on beyond high school graduation. The increasing concern with the needs of this larger part of the high school population has inevitably been reflected in decreasing concern with the needs of those whose training has only begun and who must continue on through the college and the graduate school. Unquestionably this appears to be having its effect not only on the quality of the work done in the secondary school, but in the election of courses of study less likely to direct the interest of students into courses preparatory to science and engineering. Besides this there appears definitely to have been increasing difficulty in holding high school teachers or in recruiting new ones of substantial training in pre-science and pre-engineering courses. Not only have job opportunities lured high school graduates into employment directly, but they appear also to have lured away high school teachers. There is, unfortunately, inadequate quantitative information on which the validity of these remarks can be tested or the magnitude of the phenomenon discussed, but if present indications are true it is a problem of utmost importance and worthy of attention.

To meet the present situation it will be necessary to break completely new ground. The present role of the highly trained specialist is so fundamental to our national welfare and our national security that the problem becomes one in which a national point of view must enter. It is also true that there must be a recognition that the training and utilization of personnel for the many activities which require advanced training is just as important and must receive just as much attention and recognition as the training and utilization of combat forces. This point of view is not adequately reflected as yet in national policy nor in national programs. Our whole concept of manpower policy is as yet inadequate to the special circumstances of the present. The experiences of the past have been largely inapplicable to meet the present situation and yet the shadow of the past hangs heavy over any attempts to achieve policies realistic under present circumstances. Selective Service policy in the past, for example, was conditioned by the special circumstances of World War II. The habit at that time was to make the decision as to whether an individual were to remain in his employment or enter the military service based upon the concept of essentiality to the national effort of the time. With all its uncertainties, nevertheless it provided a philosophic basis for an individual decision which could at least theoretically be considered an adequate criterion. It, of course, did not reflect in any way the fact that even after a war the activities

of the nation must go on and other emergencies must be provided for. Under present circumstances this philosophic basis is obviously quite inadequate. The present situation is one in which the emphasis should be much more largely on long-time preparation for the necessities of an uncertain future than for the requirements of the present.

Some attempt has been made to reflect this new point of view in the Selective Service regulations established by the President to cover the deferment of students. You are, of course, familiar with the details of this plan. The plan is now in operation and much of the testing, which is a conspicuous feature of the plan, has actually occurred. Approximately ⅔ of the students who have applied for tests have been tested and the third and fourth contingents will very shortly take their tests. The program at the present time appears to be working as smoothly as can be expected. The tests, themselves, have met general approval on the part of the students and the public press. The attitude towards the program on the whole has been steadily shifting to a greater degree of approval on the part of the general public. The Gallup Poll on May 26 published the results of a nation-wide survey of public opinion on the deferment program and announced that on the whole the general public approved the plan. Fifty-five per cent of those interviewed expressed approval; 36% expressed disapproval and 9% were undecided. Curiously enough, when those interviewed were broken down into categories in terms of their training, it was found that those with only grade school training approved the program in the ratio of 58–32, almost two to one, while those with college training approved the program in a ratio of 56–37, a ratio of about three to two; those who were listed in "Who's Who" endorsed the program in the ratio of better than 2–1 or about 66–31.

The attitude of draft boards and the State Directors of Selective Service appears to have improved substantially and there is now a general feeling of confidence in the National Headquarters of Selective Service that there will be no great difficulty in the administration of the program.

There remains, however, still a problem with regard to the deferment of persons whose training has been completed. There is less desire on the part of draft boards to defer, what appears to them to be indefinitely, a young man with advanced training, even in spite of the fact that he may be in a category in serious short supply and of considerable importance to the mobilization effort. Similarly, the problem of Reservists has not yet been adequately met. Decisions on requests for deferment on the part of Reservists called back to active duty are as yet achieved by procedures developed some time ago and reflect essentially the military need for these individuals much more than they do civilian requirements.

Underlying both of these problems is a dangerous assumption. The difficulty of retaining specialized personnel in a civilian activity is to a large extent due to the assumption that the individual will be called in for a relatively short period of service and then returned. The length of service required of draftees is twenty-four months and for Reservists with military service in the last war requests for discharge may be made after seventeen months. However, it should be noted that in the present world situation there can be very little guarantee that this length of service will be all that is required. In actuality, any substantial increase in hostilities within the next twelve months requiring increased mobilization will undoubtedly present a military situation which will be completely overriding in the disposition of individuals in the Armed Services, for it will be impossible under such circumstances to withdraw individuals actively built into positions of importance in the military service on the basis of a civilian specialty. National policy is still a far cry from reflecting a realistic understanding that national security is grounded solidly on more than one pillar of support, the military arm, but rests also on at least one

other pillar, a vital, versatile, and vibrant technology.

It has long been apparent that if national policy is to achieve a sound basis in realistic understanding of the problem of training and utilization of scientific and engineering manpower, then there must be some one central place in the Government where such matters are focused. This led to the recommendation to the National Security Resources Board by the Engineering Manpower Commission of the Engineers Joint Council and by the National Academy of Sciences and other groups that a national scientific personnel board be provided for in the new Selective Service Act. The Congress did not see fit to consider this recommendation when it was submitted to them through the Thomas Committee of the NSRB. Nevertheless the concept of a central policy committee to deal with such matters was not entirely lost.

Perhaps the most important development up to the present is the establishment within the Office of Defense Mobilization of a Committee on Specialized Personnel, appointed by the Director, Mr. Charles E. Wilson. This Committee will have responsibility for reviewing and initiating policy recommendations in the whole field of specialized manpower, including Selective Service, the problem of Reservists and of Civil Service employees. The Committee will also inquire into the implementation of policies by the Government. The Committee is composed of persons within the Government and non-Government personnel in approximately equal ratio. Some of the members from within the Government are the Director of the Science Foundation, Director of the National Advisory Committee for Aeronautics, Chairman of the Research and Development Board, Director of the Defense Manpower Administration, and the Commissioner of Education. The non-Government members have been selected from the fields of the sciences and engineering and include a representative of the social sciences in the person of Dr. Douglas Brown, Vice-President of Princeton University. The two members of the Engineering Manpower Commission are Messrs. Harry W. Winne of General Electric and Dean S. C. Hollister of Cornell University. Besides this Committee, there are now permanently established Advisory Committees within the Selective Service System for dealing with matters which are peculiar to that agency. These groups are important in that they furnish for the first time official bodies at policy levels where matters relating to these important issues can be centered for policy discussions.

However, in this problem it should be emphasized that the major difficulty is that of public awareness of the magnitude and importance of the problem. For this reason it is extraordinarily important that an organization such as the Engineering Manpower Commission be in existence. The EMC has a challenge and a function made even more important by the existence of such agencies as I have described in the Federal Government. They can furnish a channel through which information can be brought to those responsible for policy. They can take a leading part in the important function of disseminating information for the education of the lay public, for the information of employers and for the guidance of training institutions. They can present to the public, to the Congress and to the Federal Administration considered opinions of the engineering personnel of the nation for the guidance in dealing with policy matters. If I may make any statement in conclusion, therefore, it is to urge that every effort be made to strengthen the hands of such an organization as the EMC in order that it may play to the full its key role in assisting to secure an alleviation of the present crisis condition, in working for an augmented flow of persons in training, better support for engineering education and better utilization in the national interest of the personnel already trained and on the job.

National Science Foundation Developments*

By A. A. POTTER

Dean of Engineering, Purdue University Member; National Science Foundation Board

Basic Research a Foundation for Invention

America's present industrial supremacy may be traced largely to the fact that this country has had a type of government which has encouraged its people to invent, to translate their inventions into marketable products, and to manufacture such products in quantity and at a cost to stimulate and satisfy public demand. The welfare of our country in the future, even more so than in the past, will depend upon its scientific and technological developments and these, in turn, will require people who have ability to create basic scientific knowledge.

In the past, our inventors were fortunate to be able to draw upon the basic science findings of other countries, mainly Europe. Unfortunately, two world wars have greatly depleted the human and material resources of other lands, so that for many years in the future, the U.S.A. has the responsibility for building up a stock pile of basic scientific knowledge. Our great asset as a nation has been our ability to convert scientific knowledge in practical utility. Basic research, on a scale commensurate with the dominant position of the U.S.A. in applied research and invention, is essential to protect the industrial and technological competence of our people. Unless we lay the foundation of basic research for the practical discoveries and inventions, we shall fall short in the future as a creative people.

E. V. Murphree, President and Director of the Standard Oil Development Company, in the *American Scientist* for April 1951, states:

"Our health, our industry, our agriculture, and our weapons for national defense are all based on the application of scientific knowledge. This scientific knowledge has been slowly built up through the years by basic research. Without the foundation laid by basic research, the remarkable advances in our standard of living and the nation's health, which have occurred steadily through the years, would have been impossible. It is clear therefore that the proper support of basic research is fundamental to our progress and to our survival as a nation."

Dr. Murphree also calls attention to the fact that "Penicillin is the product of basic research" and that "one of the strongest reasons why Soviet Russia has not overrun Europe is our greatly superior position on atomic bombs—the most spectacular creation of basic research."

National Science Foundation Endorsed by Leaders

For a number of years, there has been a nation-wide demand for the creation of a National Science Foundation and its importance has been recognized by official statements by the President, the only living Past President, Herbert Hoover, in the hearings, conferences, and debates of several Congresses, and in writings and statements of outstanding scientists, engineers, physicians, military leaders, educators, and industrialists.

While opposing government control of

*Paper presented at the 59th Annual Meeting of The American Society for Engineering Education at East Lansing, Michigan, June 26, 1951.

education and research, the leaders in science and engineering recognize the following successful precedents for the establishment of a federal agency for the support of advanced education and research in the sciences:

(1) The Morrill Act of 1862 and the later Morrill-Nelson Acts under which the nation-wide system of Land-Grant colleges and universities was established.

No harmful effects on the national system of education or on the Land-Grant institutions themselves have resulted from the support derived from Federal grants under the acts, but those colleges have contributed richly to American agriculture and industry.

(2) The Hatch Act of 1887, establishing the Agricultural Experiment Stations of the country, and the subsequent Adams Act, Purnell Act, Bankhead-Jones Act, and the Research and Marketing Act amending the Bankhead-Jones Act, providing Federal aid for agricultural research, have been of the greatest benefit to the nation at large and particularly to its farm population.

(3) The Act establishing the National Bureau of Standards, a division of the Department of Commerce, has resulted in better standards of value to the public.

(4) The Act establishing the National Advisory Committee for Aeronautics, an independent Federally-supported agency having as its purpose the development, through research and experimentation, of improved methods of air transportation. It is widely agreed that NACA has rendered service of the utmost importance to the science of aviation.

Thus, in the fields of higher education, agriculture, maintenance of standards, and the specialized field of development of aeronautics, support given by the Federal Government to research has been of very great importance without causing injury to private business or the domination of industry. It has long been recognized that similar aid rendered on a broad basis and safeguarded as in the present National Science Foundation Act would be of similar benefit in the fields of basic science.

We have reached a stage of such complexity in scientific endeavor and cost of equipment necessary for basic research is so great that universities and private research foundations have insufficient resources to go forward speedily in creating new knowledge. Thus government aid for basic research is essential. In so far as industry is concerned, there is a limit as to the amount it can expand for long range basic research projects. Many American industries are well equipped to invent and carry on programs of basic as well as of applied research, but few have the means for basic research which has a remote connection with immediate gains.

Objectives of National Science Foundation

In the National Science Foundation Act of 1950 (Public Law 507, 81st Congress, S247) the Foundation is established in the executive branch of the Government as an independent agency. The Foundation is authorized and directed, among other functions, to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences; to initiate and support basic scientific research in the mathematical, physical, medical, biological, engineering, and other sciences; to award scholarships and graduate fellowships in the above fields; to foster the interchange of scientific information among scientists in this and in other countries; to maintain a register of scientific and technical personnel; and to initiate at the request of the Secretary of Defense research projects in the interest of national defense.

The primary responsibility of the Foundation is to develop a sound national policy for the promotion of basic research and education in the sciences. This will require the best thinking of the most competent of our people. To supplement the Board and the Staff, the

Foundation is authorized to establish special commissions to make comprehensive surveys of research, both public and private, recommending to the Foundation an over-all research program in the field of the survey. It is hoped that several such commissions will be functioning during the next year. It is expected that the thinking of organized scientific groups, including professional societies, will also be utilized in developing a national science policy.

The next most important task of the Foundation is to evaluate through factual surveys the need for research in the several basic scientific fields, with special reference to our national interest, and to provide emergency support in the directions of greatest need.

The Act authorizes and directs the Foundation to award "scholarships and graduate fellowships in the mathematical, physical, medical, biological, engineering, and other sciences." No decision has been reached about the support of undergraduate scholarships, but this problem is being studied by a committee of the board. There is, however, a most urgent need for graduate fellowships, as large numbers of our superior and potentially creative young people stop with the Bachelor's degree because of inadequate financial support. It is estimated that in the three-year period, 1947 to 1950, over 14,000 potential candidates for the Ph.D. degree in the sciences were prevented from entering graduate schools because of the lack of funds. In the immediate future, this problem will become more serious, as approximately one-half of the graduate students in the years, 1948–50, received G. I. benefits. The Foundation hopes that appropriations by the Congress will make it possible to provide about 2000 pre-doctoral and at least 100 post-doctoral fellowships during the fiscal year, 1952–53. These will make up only about 3.6 per cent of the graduate students in the fields of science, engineering, and medicine. The National Research Council, because of its 30 years of successful experience in fellowship programs, will administer the Foundation's fellowship program in the opening year, but appointments, as required by law, will be made by the Foundation. It is felt that the graduate fellowship program should be given preference by the Foundation to undergraduate scholarships at this time in order to insure an adequate supply of man power with the necessary tools for research in the basic sciences. Especially the post-doctoral fellowships should develop the future leaders in research and education as mature scientists, who have already received their doctorate, will thus be able to spend one or two additional years on specific problems in scientific research.

Starting Date for Fellowships Has Not Been Determined

Serious problems exist in the dissemination of scientific information, both internally in this country and in obtaining for our scientists the benefit of scientific information developed in other countries. The foundation hopes to be able to aid in the exchange of information in the following ways:

The staff of the Foundation expect to undertake a study to determine in which areas publication facilities are lacking or inadequate, where gaps exist in the major collections of scientific literature and how those gaps can be closed, and factors which contribute to a lag in publication of research results. The Foundation also expects to sponsor research to develop new techniques for the quick and economical dissemination of scientific information. The Foundation hopes that its means will make possible more travel by American scientists to scientific meetings in other lands in order to broaden their contacts.

In formulating a national policy for science and in planning for mobilization of scientific effort in case of a national emergency, comprehensive information about man power is essential. The national roster of scientific personnel was established at the beginning of the Sec-

ond World War to supply this information and has demonstrated its usefulness. In 1949, the National Securities Board concluded that the establishment of the roster on a broad basis was essential to our mobilization readiness. Pending the passage of the National Science Foundation Act, the U. S. Office of Education activated and administered the National Scientific Register in a most effective manner. It is expected that the National Science Foundation will assume direct operation of this Register some time during the fiscal year, 1951–52. It is expected that the Register will not only continue the registration of scientists and the analysis of their experience, but will prepare and publish statistical studies of the personnel included in the Register, and will develop and maintain a clearinghouse of information on scientific personnel.

As soon as the Congress makes appropriations for the fiscal year 1951–52 the Foundation will be ready to receive proposals for basic research.

While the Foundation hopes to concentrate its efforts on basic research, it is ready to cooperate, at the request of the Secretary of Defense, on other types of research in the interest of national security.

The National Science Board

The Foundation is directed to have a National Science Board of 24 members appointed by the President, by and with the advice and consent of the Senate. The Board is expected to be representative of the fields of basic science, medical science, engineering, agriculture, education, and public affairs, and is expected "to provide representation of the views of scientific leaders in all areas of the Nation."

The Board of the National Science Foundation has held six meetings up to date. It elected James B. Conant, of Harvard University, as Chairman of the Board and D. T. Bronk, of Johns Hopkins University, as Chairman of its Executive Committee. Acting upon the nomination and advice of the Board, the President of the United States of America appointed Alan T. Waterman, of O. N. R., as the first Director of the Foundation.

The Board set up the following divisions:

1. Division of Medical Research.
2. Division of Mathematical, Physical, and Engineering Sciences.
3. Division of Biological Science.
4. Division of Scientific Personnel and Education, which is to concern itself with graduate fellowships in the mathematical, physical, medical, biological, and engineering sciences.

The Director of the Foundation was requested to contact the major societies for nominations to membership in the several divisions, as the Board is to concern itself largely with policies and not with operation.

The Engineers Joint Council, at its meeting in New York on May 18, 1951, took the following actions with relation to the National Science Foundation:

Mr. Davies read a letter from Dr. Alan T. Waterman, Director of the National Science Foundation, dated April 23, 1951, asking for suggestions of names of engineers suitable for appointment as members of the Divisional Committee of Mathematical, Physical and Engineering Sciences of the Foundation. After discussion, it was VOTED:

> that the Secretary of EJC request each constituent society to report promptly names of three members suitable for appointment by the Director of the National Science Foundation to this Committee.

The members of the Committee on Engineering Sciences were asked to aid the secretaries in choosing names of appropriate engineers.

After further discussion on the work of the Foundation, and manner in which its funds were appropriated; the need for

properly trained personnel, etc., it was VOTED:

that the Committee on Engineering Sciences, in consultation with the Committee of Secretaries, compose a letter to be sent by the Secretary of EJC to Dr. Waterman of the National Science Foundation, along the following lines:

(a) that EJC took an active part in promoting the establishment of the National Science Foundation; (b) that EJC is vitally interested in the activities of the National Science Foundation; (c) that present EJC interest is indicated through the appointment some months ago of a special Committee on Engineering Science; the specfic purpose of which is to cooperate with the National Science Foundation in matters of basic research and education in engineering science; (d) that this Committee is composed of two members of each of the five constituent engineering societies of EJC. The Chairman of the Committee is Dr. Boris A. Bakhmeteff (ASCE). Its other members are Dean Thorndike Saville, ASCE; Dr. A. M. Gaudin, Dr. R. M. Brick, AIME; Professor A. G. Christie, Dean A. A. Potter, ASME; F. M. Farmer, M. J. Kelly, AIEE; Earl T. Stevenson, Dr. Chas. M. A. Stine, AIChE; (e) that Engineers Joint Council expresses the hope that there will be established a close relationship with this Committee to the end that the engineering profession may assist to the maximum in furthering the objectives of the National Science Foundation, and (f) that communications to the Committee may be addressed to the Secretary of EJC, or directly to the Committee Chairman, Dean Thorndike Saville, New York University, New York 53, N. Y.

Basis Research in Engineering

Some people are of the opinion that basic research is confined largely to mathematics, physics, chemistry and biology. Actually, many of the problems now confronting industry and the engineering profession cannot be solved without new basic engineering knowledge. As concrete illustrations:

We need more knowledge on contact catalysis and on the kineties of steam-carbon and carbon dioxide-carbon reactions. Contact analysis is of vital importance in the conversion of coal to liquid fuels and it is also of potential importance in coal gasification.

We need to know more about the mechanism of combustion and coal structure. There are certain sciences basic to engineering which are no longer of interest to physicists and chemists, such as fluid mechanics, elasticity and plasticity, heat transfer, and electronics.

The Director as the Key Person

Finally, the effectiveness of the National Science Foundation will depend upon the Director, who is the key person in any research organization. The Science Board, made up as it is of very busy people, can concern itself only with major policy matters. The Director must have the breadth, vision, and wisdom to plan, approve, supervise, coordinate, and evaluate research programs at the cooperating laboratories; must interpret the findings of these laboratories so that they are comprehended by the public; and must have ability to command the confidence of the White House, Congress, cooperating organizations, National Science Board, and of the public at large. We are fortunate in having Dr. Alan T. Waterman as the first Director of the Foundation. He, as well as the National Science Board, however, will need the active cooperation and advice of engineers in insuring that basic research in engineering is carried out on a scale commensurate with its importance to American industry and security.

An All Powerful Engineering Organization is Needed

By T. H. EVANS

Dean of Engineering, Colorado A. & M. College

As most engineers now know, there was formed almost two years ago by EJC a committee to explore the desirability of establishing some means of increasing the unity of the profession. The committee was to be composed of 16 of the leading engineering technical and professional societies in the country, and is known as the Exploratory Group. Recently this Group has come out with four plans that are recommended for consideration as possible vehicles by which to achieve such unity. The plans are designated Plans A, B, C, and D. Plan A is essentially an expanded EJC with still a severe limitation on membership. At the other extreme is Plan D which is nothing more than the present National Society of Professional Engineers. B and C are compromises on A and D respectively. While the initiation of this vital move on the part of EJC is to be highly commended, there is no assurance that the profession as a whole will accept either of the plans as they now stand.

The following views about unity in general, and certain of the plans in particular, are not only those of the author but also of numerous acquaintances in the profession. Most of us have been hoping for many years for a chance to do something to unify the profession and for a chance to express ourselves on the matter. The move by EJC has provided that opportunity. The profession missed the boat by not unifying during its early development instead of permitting *only* autonomous technical societies to build into small but powerful organizations. We will now have to do in reverse the logical procedure that was followed by the American Medical Association in achieving outstanding professional strength first. It is hoped we will not miss the boat again while there is an unusual opportunity to unify. If all selfish interests to preserve certain relatively minor rights and powers can be forgotten in light of the bigger needs of the profession as a whole, then we can gain real unity.

Aside from any comments regarding the specific unity organizations proposed, it is believed we must first establish an objective. To a great many engineers the primary justification for unity in our profession is to achieve adequate economic and professional recognition of the character already gained by the powerful Medical profession. Such an objective is vital if we choose to establish Engineering as a real profession. It is hard to believe we will ever do it unless we have an organization that can include *all qualified engineers*. If such an organization is established we should have a potential even more powerful than the AMA because of the greater numbers involved. Whether we like it or not, it takes power through numbers to gain proper recognition, legislation, and action in these times. While most of us would condemn the lack of ethics, lack of public interest, the ruthlessness, and violence practised by the labor unions, we still must recognize their strength and power, which was gained through numbers. If we wish to achieve higher eco-

nomic and professional goals (and I believe most of us do) we must do it through an organization that has real power, as well as represents the Engineering profession. If true unity is not gained now there is a good possibility that a number of strong engineering collective bargaining groups, which are growing and consolidating, will provide what a lot of engineers feel is all they need. It is astounding to learn just how strong some of these organizations are, and they are expanding rapidly.

There seems to be an undercurrent in the Report of the Exploratory Group that any Unity organization is supposed to be subservient to the technical societies and National Society of Professional Engineers. If this is the intent of each of the four plans proposed then it appears to many to be entirely contrary to the needs of our profession. Many of us believe the unity organization should be THE Society and all others secondary to it. It is true we can never do without the technical societies as far as technical development goes, but what is the use of achieving technical supremacy if bricklayers, plumbers, rolling mill foremen, etc., through their unions, steal the ball and gain more from it than do those who create the improvements? In studying the four plans thus far proposed, it appears there is an attempt to preserve existing power within presently autonomous organizations and lack of recognition of the primary need, which is *one all-powerful group* to represent the Engineering profession. Why shouldn't existing groups that have the interest of the profession at heart merely lend themselves to helping their members and other qualified engineers to achieve a real unity organization? If gaining true unity in the profession means shifting the technical societies to a relatively subordinate position, many of us who are loyal and devoted technical society members can see no harm done. It is understood the Medical profession operates in such a fashion and we have a long way to go to equal them. The technical worth of the present societies would not be diminished at all.

To get down to specific plans proposed by the Exploratory Group it appears that Plan C comes closest to the objectives expressed above but it would need some major alteration in the plan of management and membership. It is not believed the technical societies should be predominant in the governing body, except through their members as "individual members" of the unity organization. Each individual member should have his one vote in determining directly the management and policies of the Unity organization.

One state branch of a national founder society has appointed a committee to study the four plans proposed, as well as the matter of unity in general. This committee has made a recommendation that contains five points substantially in accord with the above views. It is hoped that with real awakening of a grass roots interest in this vital matter something significant and useful will result.

Engineering educators can play an extremely vital role in stressing the need for real unity in this grand profession of ours.

Heat Transfer and Liquid Metals in Nuclear Reactors*

By RICHARD N. LYON

Principal Development Engineer, Oak Ridge National Laboratory

The rate at which heat can be removed from a nuclear reactor determines the rate at which the nuclear chain reaction can safely be operated. Heat arises largely from slowing the fission-product atoms. Two of these heavy atoms result from each fission, and they fly apart with a total energy of more than 150 million electron volts. The range of these atoms in solid matter is such that the heat is generated within the reactor fuel itself.

One problem, then, is the movement of heat out to the surface of the fuel. For simple geometries, the design is not difficult, but distortion of the heat flow pattern outside the fuel is reflected in distortion of the heat flow pattern within the fuel.

Protection is often required for the fuel material by a jacket or coolant conduit. The contact between the jacket and the fuel is of great importance. Not only can this be a source of serious thermal resistance, but also nonuniform contact can cause thermal stresses and distortion of the fuel element. It may also give rise to over-heated regions on the jacket.

Conduction through the jacket offers no serious complication unless fins or spacers are provided. Because of the high heat fluxes involved, even thin scale deposits are to be avoided, and a noticeable resistance may even occur in some cases where the coolant does not wet the jacket.

Proposed reactor coolants range in density from hydrogen to molten lead. Among other properties, coolants should possess the following to a greater or lesser extent:

1. Low neutron absorption.
2. Low corrosion rate with suitable jacket and conduit materials.
3. High thermal conductivity.
4. High heat capacity.
5. Large useful range of temperature.
6. Good chemical stability in nuclear radiation.
7. Simple pumping and plumbing requirements.

Liquid metals have been proposed as meeting most of these requirements. Some of them have low neutron absorption, they can be contained in usable conduit materials and they are are not subject to chemical decomposition.

Their useful range of temperature is larger than with any other liquids, and the thermal conductivities of liquid metals are higher than those of any other fluids.

The high conductivities of liquid metals have led to a difficulty in predicting the thermal resistance between the fuel jacket and the bulk of the coolant. Where the conductivity is high, its effect extends well into the turbulent region of flow and standard equations for the heat transfer coefficient cannot be used with assurance. Professor Drew and S. A. Isokoff at Columbia and Brookhaven have recently demonstrated the first point by measur-

* Presented before the Middle-Atlantic Section of the ASEE, Rutgers University, May 12, 1951.

ing the temperature distribution across a turbulently flowing mercury stream in a heated tube. Martinelli was the first to predict the fact that the usual relationships could not be applied. At Oak Ridge National Laboratory the approximate equation $Nu = 7 + .025\ Pe^{.8}$ was proposed and its applicability has been demonstrated by several investigators.

Not all liquid metal heat transfer coefficients have been predicted by the above equation, however. Mercury, lead, and lead-bismuth alloy frequently fail to give as high coefficients in experiments. It has been suggested that this is due to poor contact between the liquid and the wall caused by non-wetting. Under this condition, the liquid is supported on the peaks of the wall roughness, and a region only partly filled with metal results. Further work is needed to prove or disprove this theory.

Plumbing problems with liquid metals are no more severe than the problem of handling radioactive liquids. In both cases, leaks are to be avoided. At moderate temperatures, small leaks in non-radioactive liquid metal systems cause only minor difficulties. At high pressures and elevated temperatures small leaks may become eroded into large leaks. Liquid metal systems have been operated at temperatures over 1600° F. without mishap.

The electrical conductivity of liquid metals can be used in pumping and metering. A variety of "electromagnetic" pumps and flowmeters have been developed and used with considerable success.

To stimulate research and use of liquid metals outside the atomic energy project, a Liquid-Metals Handbook was published last summer. Since that time 2500 copies have been sold and the book is now out of print. A second edition is being drawn up and will be available next fall.

College Notes

R. Norris Shreve, head of the School of Chemical and Metallurgical Engineering at **Purdue University**, will retire at his request from headship of the school to devote his time to teaching, research and writing. He will be succeeded by Edward W. Comings, professor of chemical engineering at the University of Illinois. Announcement of the change was made by Dean A. A. Potter, of all the Schools of Engineering at Purdue.

Ivan C. Crawford, dean of the College of Engineering of the University of Michigan, will join the **University of Denver's College of Engineering** faculty at the end of the current academic year. Dean Crawford has served as dean of Engineering at three major institutions—University of Idaho, University of Kansas and University of Michigan.

Gifts of $1,175,000 toward a Materials Testing and Processing Laboratory under construction at **Cornell University** were announced.

Completion of the units in early 1953 will enable the engineering college to undertake new defense research, according to S. C. Hollister, Dean of the College.

Properties and Requirements of Materials in Nuclear Engineering*

By DAVID H. GURINSKY

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The selection of materials is dictated by the conditions of service to which the material will be subjected. This is the basis for selection in the field of atomic energy as in other fields. Most of the same criteria apply in this new field, such as yield strength, tensile strength, creep strength, corrosion resistance, etc. However, as in any specialized field, certain properties assume greater significance. If one has to select the one property which is novel and important to the field of atomic energy, it is the cross section. If the element, or alloy, is to be used in a reactor, its cross section must be known. If the cross section is too large, it cannot be used, since the neutron economy may be upset.

The absorption cross section for neutrons is defined as the area of the nucleus for absorption. The microscopic cross section has the dimensions cm^2 and is given in barns. One barn is defined as 10^{-24} cm^2. The engineer is actually more interested in the macroscopic cross section, which is the product of absorption cross section σ_a and number of atoms per cubic centimeter (N).

In the field of aeronautics, materials are compared on their strengths per unit weight. Likewise, one may arrive at a figure of merit for materials which may be used in a reactor. To obtain a comparison of materials, one selects the property of interest and divides it by the macroscopic cross section. By way of illustration, the following elements and alloys have been arranged according to their decreasing merit, with yield strength as the property of interest (Table I). The yield strength selected was that obtained on annealed material. Some of these materials are not ordinarily used in the annealed condition. It can be seen that if the yield strength of a steel could be increased by a factor of 5 and this is possible then the quality factor would be 0.8. Only in this condition does steel start to compare favorably with annealed magnesium and zirconium. It is still not as desirable as Be on this basis.

There are, however, other quality factors which need to be computed such as the creep strength at elevated temperature. In this case, the order will probably be different. At high temperatures the stainless steel because of excellent creep resistunce should show up favorably even though the cross section is high. It becomes apparent then that the conditions of service will, even in

TABLE I

	Yield Strength $lb/in^2 \times 10^3$	σ_a cm^2 10^{-24}	F.M. $\times 10^3$
Be	26.	.009	23.6
Mg	14.	.4	0.88
Zr	15.	.5	0.71
Al	5.	.23	0.42
St. Steel	40.	2.8	0.19
L. C. Steel	30.	2.6	0.16

* Presented before the Middle Atlantic Section of the ASEE, Rutgers University, May 12, 1951.

atomic application, be a determining factor in the selection of materials.

Radiation Properties

Thus far, we have considered one new physical property of materials (namely the cross section) as a basis for selection. There is an environmental aspect which is also new and has a real bearing on the kind of material which is recommended for a particular use. One must ask, will this material be stable to "Radiation"? Although there are four basic types of particles or radiation, fission products, neutrons, Beta and Photons, present in a reactor, only the first two are of importance to metals and alloys.

I shall discuss in general terms only the effect of neutrons. If a fast neutron strikes a nucleus of a metal it has sufficient energy to knock the struck atom out of its position in the lattice. The energy of the struck atom is given by

$$\Delta E = E_0 \frac{2A}{(A+1)^2}$$

where E_0 = initial energy of the neutron,
ΔE = loss of energy of the neutron or energy picked up by the struck atom,
A = atomic weight of struck atom.

The original neutron can go on to strike more atoms in the lattice. Likewise the struck atom can go to knock more atoms out of their lattice positions or it may lose its energy by ionization. The damage to a lattice is then computed by determining the number of atoms which have been displaced. Dr. Slater[1] in a recent article in the *Journal of Applied Physics* has pointed out another approach to radiation damage which is statistical or thermodynamic. The argument in this type of analysis is as follows: The energy required to displace an atom from its lattice site is of the order to 25 ev.

[1] "Effects of Radiation on Materials," J. C. Slater, *J. A. Physics*, Vol. 22 (237–251), March, 1951.

TABLE II

RESISTIVITY* OF Cu_3Au SAMPLES BEFORE AND AFTER IRRADIATIONS

Neutron Flux†	Ordered Samples		Disordered Samples	
	Before	After	Before	After
0.4	4.60	5.71	11.20	11.25
0.6	4.60	6.25	11.20	11.25
1.0	4.60	7.54	11.20	11.17
1.5	4.60	8.36	11.20	11.21
3.3	4.60	10.10	11.20	11.30

* Unit of resistivity: 10^{-6} ohm-cm.
† nvt above 50,000 ev. Unit is 10^{19} n per sq. cm.

If initial energy of the neutron is dissipated amongst the atoms along its path in 25 volt increments, we will have for a 1 mev neutrons approximately 4×10^4 atoms which have been brought to the vaporization temperature. Since this high temperature region is highly localized, these regions which have been so heated quickly cool down and are quenched. Many of the atoms will not have a chance to return to their original positions. The net result is a region in the metal or alloy where many atoms have been displaced. This gives rise to a stress in the lattice. This is equivalent to work hardening.

To illustrate this effect, the published work of Billington and Siegel[2] may be cited. They selected an alloy of copper and gold for this irradiation study. The ratio of atoms of copper to gold is three to one. This alloy Cu_3Au may by proper heat treatment be obtained in the ordered condition. In this condition the atoms of gold occupy the corners of a cube and the atoms of copper occupy the center of the faces of the cube. Also by another heat treatment, the alloy may be obtained in the disordered condition, or stated differently, the atoms of gold and copper take up random

[2] "Effect of Nuclear Radiation on Metal," D. S. Billington and Sidney Siegel, *Metal Progress*, Dec.; 1950, pp. 847–852.

positions. The properties of this alloy differ markedly depending on whether the alloy is in the ordered or disordered condition.

Samples of the ordered and disordered alloys were subjected to different total irradiations. By consulting Table II, it can be seen that after an irradiation dosage of 3.3×10^{19} neutrons the ordered alloy has been almost entirely converted to the disordered form. This is striking proof of the fact that atoms are displaced from their lattice positions. Of the two methods considered for calculating the damage, the second method seems to explain the results of this experiment.

These experimenters have tested the effect of radiation on many materials by measuring the electrical resistivity and hardness changes. They found that if the material was subjected to sufficient radiation, hardness increases were observed. Aluminum seemed to be an exception. The greatest increases in hardness were observed if the original material was in the softest condition. A saturation effect was noted for beryllium copper alloys and various stainless steels.

In conclusion, if one wishes to generalize on the materials problems in the field of atomic energy, it can be stated that there is one new physical property, the absorption cross section, and one new environmental condition, radiation, which must be considered by the materials engineer in the selection of materials.

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS

ANNUAL MEETING AND EXHIBITION

BELLEVUE-STRATFORD HOTEL – Philadelphia, Pennsylvania

Meeting—Wednesday, Thursday, Friday, November 28, 29, 30, 1951
Exhibition—Wednesday & Thursday, November 28 & 29, 1951

The central theme of the entire meeting will be
EDUCATION & TRAINING for EXPERIMENTAL STRESS ANALYSIS

Technical sessions will be devoted to—techniques—applications and models—fatigue testing—stresses in the plastic range—vibration and impact—in addition, there will be a symposium on the topic of education and training for experimental stress analysis.

All A.S.E.E. members, and their friends, are invited to visit the exhibits and to attend the technical sessions. (Attendance at the exhibits will be free of charge. For any or all of the technical sessions the usual registration fee of $3.00 will prevail).

A.S.E.E. members, or friends, wishing to show apparatus or equipment should communicate directly with Mr. Greer Ellis, Chairman, S.E.S.A. Exhibits Committee, P. O. Box 77, Pelham 65, N. Y.

Inquiries relating directly to the meeting should be addressed to Mr. Bruce L. Sutton, Co-Chairman, S.E.S.A. Meetings Committee, c/o Baldwin-Lima-Hamilton Corporation, Philadelphia, 42, Pa.

The S.E.S.A. will be glad to send you a program if you will direct your request to either of the above, or, to the Society for Experimental Stress Analysis, P. O. Box 168, Cambridge 39, Mass.

Technical Information Services at Atomic Energy Laboratories*

By D. PULESTON

Brookhaven National Laboratory, Upton, New York

The following description of the technical information services provided at Brookhaven National Laboratory is intended to present a general picture of a typical technical information organization at any one of the larger atomic energy research laboratories in this country. The main difference, in the case of Brookhaven, lies in the fact that the proportion of unclassified work to secret is somewhat greater than at other installations. This, of course, has had the effect of increasing our responsibility to disseminate information to the widest possible extent.

Before launching into a detailed discussion of the information work itself, it would be well first to describe the Laboratory's organization, and by this means indicate the requirements of our scientists. The Laboratory's technical staff is organized along lines very similar to those of a university faculty. There are Departments of Biology, Chemistry, Medicine and Physics. An Instrumentation and Health Physics Department is responsible for the design and construction of electronic equipment for research and for radiation safeguards. In addition, the Reactor Science and Engineering Department and the Accelerator Department were organized to design and subsequently to operate the two large research facilities, the reactor and the high energy particle accelerators. Thus, it can readily be seen that the demands on our technical information facilities, both internal and external, are extremely varied in their fields of interest. This situation is very similar to that at the other major AEC installations.

The main functions into which our efforts are directed are as follows:

(a) The operation of the Research Library, which comprises books, periodicals and other types of publications in the open literature. It is not necessary to describe this function in this paper.

(b) The control, as required by AEC's security regulations, of incoming and outgoing classified documents, and the operation of a small library of classified Project material.

(c) The production and distribution of technical reports (open and classified) issued under the auspices of the Laboratory.

(d) The processing of papers authored by Brookhaven staff members, intended for publication in the various open scientific journals.

The Classified Library

The second item, the Classified Library, immediately points up one of the great information problems facing all AEC laboratories—the classified report. At every stage of its existence, such a document must be watched and accounted for and properly safeguarded and only permitted into the hands of those authorized to have it, while on the other hand, it is also our responsibility to ensure that it receives the optimum distribution within

*Presented before the Middle-Atlantic Section of the ASEE, Rutgers University, May 12, 1951.

the existing security regulations. An additional handicap in this procedure lies in the fact that in many cases even the title is a classified item. With these obstacles, the surest way to bring such secret material to the attention of the proper persons is by means of personal contact. The staff of the Classified Document Group have been trained over a long period in the needs and special interests of the scientists; in addition, a great assistance is rendered by the AEC publication *Abstracts of Classified Reports,* which is issued bimonthly and is circulated at all project laboratories. This publication can be considered as the classified counterpart of *Nuclear Science Abstracts.*

In contrast to the difficulties under which classified reports must be circulated, the discussion of the dissemination of open literature comes as a pleasant relief. In this case there are no restrictions, the only problem being that of weeding out from the great mass of incoming material those items that are of greatest interest, thus saving the scientist's time and yet helping to keep him abreast of the literature. At Brookhaven, we have found *Nuclear Science Abstracts* and the *Weekly Selected Reading List* extremely valuable in this respect. The first, a fortnightly Commission publication, gives excellent general coverage on all unclassified and declassified material in the fields of nuclear science and engineering. At Brookhaven, we distribute 200 copies of each issue of *Nuclear Science Abstracts* on an individual basis, at the specific request of the recipients.

Nuclear Science Abstracts is supplemented by the Reading List, already mentioned, which, since it is prepared at Brookhaven, can give a more detailed coverage in fields in which the Laboratory is particularly concerned. The titles in this weekly list are broken down into the following categories: General, Physics, Engineering, Electronics and Instrumentation, Chemistry, and Biology and Medicine. Each Wednesday, the new material—books, periodicals and reports—are culled, both by the Library staff and by the scientists themselves. Each of the scientific departments has a list of those willing to help in the selection for his own particular field, and a turn is taken each week by one of those on the list. In this way, no great burden is placed on any one individual; in fact, some of the selectors have expressed their satisfaction with the system, as a means of giving them the necessary impetus to keep in close touch with the Library. In addition to the internal distribution of 220 copies of the *Reading List,* we have received over 600 requests from other laboratories and institutions connected with the atomic energy program.

While on the subject of the *Reading List* and *Nuclear Science Abstracts,* it should be mentioned that we have developed a system for bringing such publications to the attention of new staff members who might be interested in receiving them on a personal basis. At the time that a new scientific worker joins the Laboratory staff, a check list is sent to him, together with sample copies of the various publications he may receive regularly if he wishes, such as the *Reading List, Nuclear Science Abstracts,* and the monthly *Library Acquisition List.*

Reports and Translations

A separate unit within the Technical Information Division is concerned with the preparation of Brookhaven reports, both open and classified. Such reports can be broken down into the following categories: Laboratory progress reports; technical reports covering single phases of research; conference reports containing the papers presented at scientific conferences held under Laboratory sponsorship; and the *Guide to Russian Scientific Periodical Literature*

This last named item is worthy of particular mention, since it is somewhat unusual in its scope. Since early 1948, Brookhaven has been issuing translated lists of titles from the outstanding Rus-

sian scientific periodicals, notably the journals published by the USSR Academy of Sciences. Seven issues appeared during 1948, but since the beginning of 1949 the *Guide* has appeared on a basis of twelve issues per year, with a cumulative index included in the last issue for each calendar year. In addition, some translations of abstracts are also given, and, in certain cases, translations of full articles in the field of nuclear physics.

The project was originally instigated as a result of the abandonment in late 1947 by all Russian scientific periodicals of the practice of publishing in English the titles and abstracts of their articles. Previously, such material had been available in English, French, and German. In spite of this lack of cooperation on the part of the Soviet Government, it has still been possible, though not always easy, to obtain copies of their outstanding scientific journals within several months of publication. In addition, a number of other organizations in this country, Canada, and Great Britain are cooperating with Brookhaven by submitting to us copies of any Russian translations they may have made; the titles of such translated articles are listed periodically in the *Guide,* and are available for loan from the Research Library. While the *Guide* is proving very useful to a number of our physicists, particularly those concerned with cosmic ray work, it must also be considered as a service to all those interested in solving the mysteries of scientific research behind the Iron Curtain.

Distribution of Reports

After reproduction, the question of distribution naturally arises. In the case of secret reports, this is all too easy; copies are sent only to those organizations authorized by AEC to receive them. The Commission periodically issues lists of subject categories, with an appropriate distribution list for each category. Such distribution lists are rigidly adhered to. In the case of open publications, we feel, and are encouraged to feel, that we should give as wide a distribution within the atomic energy project as is necessary. Thus, we can distribute to any of our staff members or consultants who needs the material, any individual working at one of the universities or industrial installations cooperating with or holding a contract with the Commission, and the various cooperating government agencies. In addition, there are two standard distribution lists we follow automatically; one is the AEC list, and the other is the list of Government Document Depository Libraries authorized to receive all our unclassified material—some 200 public and university libraries located all over the country. Then, to make such material even more accessible to industry and the general public, copies are offered for sale by the Office of Technical Service, Department of Commerce, Washington, D. C., which is the properly authorized document sales agency for reports emanating from within the Commission's laboratories.

Another problem is presented by the papers written by Laboratory staff members for publication in the scientific journals. Naturally, when such a paper covers research conducted on AEC funds, it is necessary to ensure that the necessary checks for patent significance have been made, that it contains nothing of a classified nature, and that there is no statement that might be of questionable policy nature. At Brookhaven, these checks are made without undue delay by having the various departmental secretaries prepare the manuscripts on ozalid, so that sufficient copies can be run off for the checks to be made concurrently, with copies also available for the patent records, Director's files, departmental files, etc. When all the necessary clearances have been obtained, the paper is submitted to the journal, and a copy is also forwarded to the Commission's reproduction facilities at Oak Ridge, so that it can be abstracted in *Nuclear Science Abstracts,* and possibly reproduced

as an AEC document, if there appears to be a considerable delay before it can be published in the journal for which it is intended.

Technical Information Panel of AEC

This concludes the description of the main technical information service (apart from the Library) provided at one of the major AEC laboratories, but it only gives one side of the Commission-wide picture. No services such as ours could hope to be anywhere near adequate without the close cooperation of the other laboratories, or without the overall coordination of the Technical Information office in Washington. In such an enormous organization as AEC, with its laboratories so far removed from each other, and the cloak of secrecy so often intervening, it is vital that, by devious but carefully worked-out systems, workers can benefit to the fullest from work conducted at other laboratories, thereby also avoiding costly duplication of effort. How this can best be done is a problem which is shared equally by all information officers and librarians, and by the Washington Office of the Technical Information Service.

The Commission has wisely recognized this fact by creating a Technical Information Panel, made up of representatives from each of the major AEC research contractors, to advise AEC on all aspects of its technical information services. This Panel, with Dr. A. F. Thompson as chairman, meets three times a year to discuss technical information problems and to make the necessary recommendations towards improving our services. Material for the agenda for one of these meetings is solicited well in advance, the agenda is then made up and circulated to all Panel members. It is thus their responsibility before the meeting to discuss with all concerned at their laboratories—librarians, document custodians, editors, and of course, scientists—the items that concern them particularly, so that the members can come to the meeting fully prepared, not only with their own views as information officers, but with the views of the laboratories they represent.

I am pleased to state that the meetings are conducted in a truly democratic spirit, that no complaint or suggestion is offered without receiving proper consideration, and that the general sentiment of all members is that the Commission is far more anxious to act upon the recommendations of the laboratories than it is to impose its own ideas upon them. Surely this is the keystone of any large technical information program such as ours, and since there is every reason to believe that it will continue to be conducted in this fashion, we can hope to surmount successfully our future problems. However, we must always bear in mind the axiom that no technical information facilities, whether they be well-stocked libraries, well-written and handsomely printed reports, or carefully formulated distribution lists, will ever be any better than the services of the technical information staffs whose responsibility it is to make these facilities available to science.

Report of Vice President in Charge of General and Regional Activities, 1950–51

The following brief resume of the activities of your Vice President for General and Regional Activities during the year 1950–51 is submitted for the information of the General Council.

I. General Activities

A. *Engineering Enrollment Statistics*

Data on engineering enrollments and degrees were collected jointly by ASEE and the Office of Education for the second year. The February issue of the Journal of Engineering Education carried the Society's publication of these statistics. The Office of Education issued a bulletin similar to the one it issued last year. The Office experiences a strong demand for these reports.

B. *Engineering Manpower Commission*

Your Vice President has served throughout the year as one of the three representatives of ASEE on the Engineering Manpower Commission of the Engineers' Joint Council.

The Commission has given wide distribution to its Bulletin No. 1 entitled "Utilizing Engineering Manpower-Deferment Procedures" as a guide to industry. Representations have been made to the Congress with respect to the length of time during which persons deferred from military service shall be liable for such service.

The Commission is conducting a vigorous campaign to place before high school students and their teachers and advisors information about the true situation in the engineering profession. Two booklets dealing with the shortage of engineers have been distributed widely, and a third is in preparation, based on a telegraphic survey of industrial and governmental needs.

The Office of Education has issued a brief statement prepared by your Vice President under the title "Young Engineers for Industry—How Many," which was written at the direct request of the Engineering Manpower Commission.

C. *Point IV*

Your Vice President reported to the Executive Board in March that the State Department was planning to request various universities to assume responsibility for the educational phases of the Point IV program in the countries to which teams are to be sent. This policy has been changed and the State Department is now channeling its programs through various Federal agencies of which the Office of Education is one.

At least for the present the educational part of the Point IV Program will be focused upon basic requirements such as literacy education, basic vocational education, and home making. There will be a few instances in which college level teachers will be recruited, but the numbers will be small.

D. *Committee on Improvement of Engineering Teaching*

Your Vice President has served during the year as a member of the Society's Committee on Improvement of Engineering Teaching on the subcommittee headed by Provost Colburn of the University of Delaware. The activities of the committee will be reported elsewhere.

E. *Atomic Energy Education*

Your Vice President has served during the year as the Chairman of the Society's

Committee on Atomic Energy Education. A report was submitted to the Executive Board in March covering the meetings of four regional subcommittees of the Committee which had been held up to that time, and transmitting a "Memorandum for Information" prepared by the Chief of the Technical Information Service of the Atomic Energy Commission at the request of the Chairman and Secretary of the ASEE Committee.

On May 8 a meeting of the Steering Committee with several representatives of the Atomic Energy Commission was held in Washington. The minutes of this meeting were sent to the Officers of ASEE and a digest of the entire year's work of the Committee has been submitted for publication in the JOURNAL OF ENGINEERING EDUCATION. It is the belief of the members of the Steering Committee that a very useful purpose is being served by this Committee, and it is the recommendation of your Vice President that the Committee be continued.

II. REGIONAL ACTIVITIES

A. *Information and Suggestions to Sections and Branches*

In September a letter was sent to all Section and Branch Officers and General Council Representatives, containing minutes of the June meeting of the Committee on Sections and Branches, a report on the September meeting of the Executive Board, and suggestions for Section and Branch activities for 1950–51.

In January the first issue of the Clearing House Bulletin for Section and Branch Officers and Representatives was issued, containing news items of general society activities and descriptions of several Section and Division activities which it was thought would be of value to these officers in planning the activities of their respective organizations. It apparently was favorably received, and elicited some suggestions for topics to be discussed by the Committee on Sections and Branches at its meeting.

B. *New Branches*

New Branches have been approved during the year at the University of Tennessee and at Texas A. & M. College. A new constitution was approved for the University of Maine Branch, based on the model constitution prepared by the Committee on Sections and Branches last year.

C. *Section Meetings*

Sixteen meetings have been reported during the year by 13 of the Society's 16 Sections (The Mid-Atlantic Section has met twice, and the National Capital Area Section three times).

All meetings have had excellent programs and have been well attended. Section officers deserve the thanks of the Society for their effective contributions to this important phase of Society activities.

At least one national officer has been in attendance at each meeting save one, when unforeseen events forced changes in plans of two officers who had expected to attend. It is hoped that this evidence of interest in Section meetings will continue in future years.

D. *Committee on Sections and Branches*

This Committee held a meeting on November 15, 1950, which was devoted in part to a discussion of the constitutional amendments providing for Associate and Affiliate Branches which were at that time under consideration, but which have since been tabled by the Executive Board.

The Committee also considered a proposal that Sections assume responsibility for the conduct of summer schools. The Committee recommended that such schools should be sponsored primarily by one of the subject matter Divisions of the Society, as they have been in the past, since a Division is interested in one particular field of education, whereas a Section might be characterized as a miniature national society interested in all phases of engineering education. However, the Committee felt that a Section might ac-

tively aid a Division in organizing a summer school if it saw fit and if satisfactory arrangements can be made between the Section and the Division. This recommendation of the Committee was endorsed by the Executive Board at its meeting later the same day.

The Manual for Section Officers which was prepared by the Committee last year is apparently proving useful to Section and Branch officers, and copies have been requested by officers of two Divisions. It is suggested that the Committee might well study the Manual further over the next year or two, with a view to possible revision and publication as an official Society document.

The Committee met on June 25, 1951, to outline plans for its activities during 1951–52. It is your Vice President's sincere belief that a major factor in the vitality and strength of our Society lies in the Sections and Branches. He feels that the reorganized Committee on Sections and Branches has already made a contribution to the Society, and is in a position to be even more useful in the future.

III. Appreciation

Your Vice President cannot conclude his two-year term of office without expressing his deep gratitude for the wholehearted cooperation he has received from the other national officers with whom he has served, from the officers of Sections and Branches, and from the members of the Committee on Sections and Branches. Whatever degree of success has attended his efforts to serve our Society has been in large measure due to the inspiration, guidance and cooperation of these gentlemen. He can wish his successor no better fortune than that he be favored with a continuation of the same cooperation.

Respectfully submitted,

Henry H. Armsby,
Vice President in charge of General and Regional Activities

ANNUAL MEETING

June 23–27, 1952

Dartmouth College **Hanover, N.H.**

Report of the Vice President for Instructional Activities of ASEE, 1950–51

The vice president for instructional activities maintains contact with Committees and Divisions, with the development of Summer Schools, and with the planning of the program for the Annual Meeting. These items will be taken up in inverse order.

The Program of the 59th Annual Meeting. Although this program is officially a responsibility of the vice president the detailed work of organization should be and has been carried out by the secretary. The function of the vice president has been restricted to consulting with the secretary when difficult decisions were to be made. This has been readily possible because of the locations of their respecfive offices in Chicago, and Evanston, Illinois. The Preliminary Program indicates that there will be very broad coverage of the field of engineering education at the Annual Meeting. The Secretary deserves to be complimented on the early publication date of the preliminary program which will have a major influence upon attendance at the 59th Annual Meeting.

The Summer Schools. Early in the year the vice president recommended approval of three summer schools and one summer conference for 1951. These were approved by the Executive Committee in October 1950, and they will be found listed in the official program on pages 30–31. In brief summary these summer schools will have the following objectives.

(1) Humanistic-Social Division Summer School, to be held June 21–23, 1951. The program is devoted to the consideration of the general problems involved in planning, developing, and teaching courses and integrated sequences in the humanities and social sciences to students of science and engineering.

(2) Engineering Drawing Summer School, June 21–26, 1951. The general theme will be "Improving our Status as Teachers of Engineering Drawing." This includes: (a) Meeting curriculum requirements; (b) Teaching methods by lecture demonstrations, and (c) Industrial applications.

(3) The Summer School in Thermodynamics will be held June 28–July 7, 1951. Topics include elementary thermodynamics, theory and advanced theory, with emphasis upon newer trends.

(4) The Civil Engineering Division is planning a conference prior to the Annual Meeting on June 23–25, 1951. The program indicates conference papers on teaching as a career, teaching techniques, electives in civil engineering and textbook selection and evaluation.

It is worthy of comment that the multiple summer-school plan shows a very healthy growth. The vice president feels that the Council made a wise decision in permitting the development of multiple summer schools. No attempt has been made to promote such summer schools, the growth observed is therefore entirely spontaneous. In this connection mention should also be made of the Fontana Summer Conference sponsored by the Southeastern Section which your vice president attended in 1950. This conference is of broader scope than the conferences mentioned above so that it attracts teachers from all fields of engineering. Another conference intended quite specifically to improve teaching and directed primarily toward young teachers was

held at Madison, Wisconsin in the spring of 1951 under the sponsorship of the North Midwest Section. It seems clear that both of these sectional conferences have served purposes similar to Summer Schools and should, therefore, be encouraged.

Committees and Divisions. The vice president for instructional activities has had regular correspondence with Division and Committee chairmen concerning such matters as Division publications, the sponsorship of summer schools, the character of the annual program, etc. Since officers rotate rapidly certain questions will need to be answered every year. It is well, therefore, for the vice president to have had considerable experience himself in Division activity.

The Special Committee on Instructional Aids. At the request of the subcommittee on Visual Aids of the Division of Educational Methods and with the approval of the Division a special committee on Instructional Aids was approved by the Executive Committee to function for a limited period of time. This committee under the chairmanship of Professor Carl Muhlenbruch of Northwestern University is now raising funds from industry to publish an index of available and approved instructional aids. The response of industry has been gratifying and the completion of this special project seems assured. This special committee will terminate its activities with the completion of this project since the Division of Educational Methods will maintain a permanent sub-committee covering this field.

The Council Committee on Improvemen of Teaching. This special committee whose establishment was approved by the Council in 1949 was not appointed as an active committee until a year ago. It had been preceded by a steering committee which effectively set the objectives for the main committee. Since the vice president for instructional activities has also served as chairman of this special committee during the past year this report will serve a two-fold purpose.

The Committee for Improvement of Engineering Teaching met for the first time at Seattle in June 1950. A list of members of the Committee is appended hereto. At Seattle it was decided to subdivide the committee into three subcommittees for convenience in meeting, each having the following objectives.

Group I meeting in New York under the Chairmanship of Dr. Alan Colburn was asked to study the problem of improvement of teaching by giving emphasis to the integration of work in the classroom, laboratory and drafting room primarily through the use of common scientific principles or basic laws. This committee is also interested in integration between fields and departments.

Group II meeting in Pittsburgh under the Chairmanship of Dean H. P. Hammond undertook to give special attention to teaching methods and techniques as influenced by such factors as class size, course objectives, limitations of physical equipment, etc. Such techniques include lecture, demonstration lecture, recitation, squad or group projects, blackboard assignments, etc. The evaluation of these techniques is being made on the basis of fundamental principles of learning.

Group III meeting in Evanston under the Chairmanship of Dr. John Calvert is investigating the development of ingenuity and resourcefulness in the student, emphasizing the importance of developing a capacity to design for most students and of research capacity for at least some.

Sub-committee Meetings. During the academic year 1950–51 Group I met twice in New York, Group II met twice in Pittsburgh, and Group III met once at Evanston, Illinois. In addition, the general chairman held a special group meeting for orientation following the ASME fall meeting in New York. The result of these sub-committee meetings is that three reports have been written which will guide the overall committee in its decisions at East Lansing, Michigan regarding how the work of the Committee shall be completed.

Institutional Committees. It was decided at Seattle to ask each engineering institution to cooperate with the ASEE Council Committee by appoining an Institutional Committee on Improvement of Teaching. Eighty of our deans of engineering have replied to your chairman's request and have furnished the names of institutional committees or of the chairman. The evidence points to the fact that well over 100 institutions have appointed such committees but some have failed to notify your chairman of their actions. Some thirty reports were received from these institutional committees on their studies, and these reports have been digested by the three groups or sub-committees. It is clear to everyone concerned that the great activity on institutional campuses during this year which was directed toward improvement of teaching is the most significant part of your Council Committee's work. We hope to stimulate continued activity of this nature into 1952.

East Lansing Meeting June 23–24. The Council Committee on Improvement of Teaching will meet in East Lansing for two days preceding the Annual Meeting. Sub-committee reports will be received and plans will be drawn for the completion and writing of a final report. The Committee expects to make its final report to the Annual Meeting at Dartmouth in 1952.

Other Activities at the Annual Meeting. The Committee for Improvement of Teaching has arranged a luncheon and discussion meeting on Monday, June 25 with representatives of institutional committees concerned with improvement of teaching. This will be a valuable opportunity for your Committee to learn of local or institutional thinking. On Wednesday, June 27, your Committee will report to the ASEE membership at the General Session. And on Thursday, June 28, the Committee will jointly sponsor a meeting of Young Engineering Teachers devoted to improvement of teaching.

This completes the activities of this Council Committee for 1950–51. If it is your desire to continue its activities it appears probable that they can be completed during 1951–52 and that the Committee should be discharged at the time of the Annual Meeting in 1952.

The above completes the report of the vice president for instructional activities for the year 1950–51.

Respectfully submitted,

L. E. GRINTER,
Vice President in charge of Instructional Division Activities

Cooperative Division to Hold Third Annual Mid-Winter Meeting

The Cooperative Division of the ASEE will hold its Third Annual Mid-Winter Meeting at Northwestern University, November 8th and 9th. The program is planned to be a part of the Technological Institute's program in the Centennial celebration of Northwestern University this year.

Annual Report of the Engineering College Administrative Council, 1950–51

Meetings

The Executive Committee to date has held two meetings as follows: Carlton Hotel, Washington, D. C., November 16, 1950; Palmer House, Chicago, Illinois, March 14, 1951. There was one hundred per cent attendance of committee members at the meeting in November, and all members except one were present for the meeting in Chicago in March.

The Washington meeting was held in conjunction with the regular fall meeting of the Engineering College Administrative Council, which by custom is held immediately following the Land-Grant College Association meeting. The March meeting of the Executive Committee was held in Chicago which seemed to be a more central location for all of our members. It was held immediately preceding the General Council meeting and we had the pleasure of the presence and the benefit of the counsel of President Dawson and Secretary Bronwell.

It is especially to be noted that it was necessary for the Executive Committee to elect a new man to its membership due to the resignation of Dr. T. Keith Glennan. This election occurred at the fall meeting. At the spring meeting the Executive Committee authorized the formation of a Nominating Committee to consider and recommend nominees for certain offices of the Engineering College Administrative Council. These offices are: chairman, secretary, and one member of the Executive Committee, all for two-year terms. The retiring member of the Executive Committee is Dean R. E. Vivian. These new officers will take office July 1, 1951. Recommendations for them will be presented and election held at the business meeting of ECAC at East Lansing, Michigan, in June.

Fall Meeting.—The fall meeting of the Engineering College Administrative Council was held at Washington, D. C., November 16, 1950, 2:30 P.M., at the Carlton Hotel. The theme of the program was "Mobilization of Engineering Education." It presented governmental, industrial, and educational attitudes, operating procedures, and plans to meet the critical manpower problems due to our expanding defense and armament program. The meeting was well attended, approximately two hundred being present. Details of this meeting are shown as Appendix II.

Annual Meeting.—Michigan State College, East Lansing, Michigan, June 25–29, 1951. The program as planned for the Engineering College Administrative Council's activities as part of the annual meeting included a business meeting of the Committee on International Relations with W. R. Woolrich presiding on June 26, and an Executive Committee meeting for members of the Committee and officers of the Society only. A joint ECAC Meeting of the Committee on Secondary Schools and Selection and Guidance was held on June 27 with W. S. Evans presiding. On June 28 the ECAC General Session had as its theme, "Manpower and Military Problems in Relation to Engineering." J. H. Lampe, Secretary, ECAC, presided. This was followed by a joint meeting of the Military Affairs and Manpower Committee with L. E. Grinter presiding. On June 29 an Executive Session for institutional representatives only was held with F. E. Terman presiding.

The Executive Session which was held in Seattle in June, 1950, was very successful. Many administrative problems of wide interest were discussed and effective comments were received from administrators of all sections of the country. The success and helpfulness of the Executive Session last year led to the planning of another special meeting for institutional representatives only. The following topics were discussed: A. Washington Report —Uncensored, which was an off-the-record report from Dean Saville; B. Special Problems of 1951–52, which dealt with accelerated programs, lower enrollments and staff reductions, business and administrative problems, under current conditions, faculty status of senior research men, salary policy, etc.; C. "Administrative problems arising from expanded research activities in the schools; D. General problems—"Up or out" plan for faculty tenure, placement service for engineers—how to operate, functional activity, how should faculty take part?

Projects of the Year

At the Executive Committee Meeting in Washington on November 16, 1950, it was decided to conduct a survey on the June, 1950, engineering graduates to determine where these men are now located professionally. This work is being done by the Manpower Committee headed by Mr. George D. Lobingier, chairman. The Manpower Committee, in conjunction with the Engineers' Joint Council, has also worked on the problem of increasing the interest of high school students in engineering as a career.

The Selection and Guidance Committee in conjunction with the Engineers' Council for Professional Development is making a study on the best way that ECAC can help in proper guidance in placement activities in the engineering colleges. Further, the Committee has worked with the Educational Testing Service on the Pre-engineering Inventory Tests.

The Committee on International Relations upon a request from the Army to nominate engineering educators for a fifteen-man panel to go to Japan for two months in the summer of 1951 organized a Commission under Dean Hammond. This Commission was headed by H. L. Hazen.

The ECAC sponsored the circulation of the bulletins of the American Council on Education to all institutional members.

News Bulletin

During the past year the ECAC *News Bulletin* was circulated six times to our institutional, associate, and affiliate members and to the ASEE officers and council members.

Informational Announcements

(I) Executive Committee Meeting, June 27, 1951

(a) *Military Affairs Committee.* In view of the immediate need for work with Federal groups and agencies with respect to Universal Military Training, a new committee for 1951–52 was immediately appointed. The Committee is as follows: W. Allan, Chairman; Messers Davis, Hawkins, Trytten, White, Norris and Wessman. Additional members may be appointed in the near future.

(b) Chairmen for other ECAC mittees for 1951–52 are:

Secondary Schools, W. S. Evans;
International Relations, L. J. Lassalle;
Selection and Guidance, H. R. Beatty;
Manpower, George Lobingierx.

(II) Business Meeting of ECAC

This meeting was held on June 28, 1951. Dean Barlow, Chairman of the Nominating Committee, made the rec-

ommendations and the following were elected for the term and office indicated:

J. H. Lampe, Chairman of ECAC and Vice-President, ASEE (term expires July 1, 1953);

W. L. Everitt, Secretary (term expires July 1, 1953);

W. T. Alexander, new member of Executive Committee (term expires July 1, 1953).

Respectfully submitted,

F. E. TERMAN, *Vice-President of ASEE in Charge of ECAC*
J. H. LAMPE, *Secretary, ECAC*

Fall Meetings **Fall Meetings**

ENGINEERING COLLEGE ADMINISTRATIVE COUNCIL
ENGINEERING COLLEGE RESEARCH COUNCIL
GENERAL COUNCIL

November 15, 1951 **Rice Hotel, Houston, Texas**

The ECAC along with the ECRC and the General Council will hold meetings at the Rice Hotel, Houston, Texas, Thursday, November 15, at 2:00 P.M. These meetings will immediately follow the annual meeting of the Association of Land-Grant Colleges and Universities, which will be held at the Rice Hotel from Monday, November 12, until Thursday noon, November 15, inclusive. Members of the ASEE are invited to attend the ECAC and ECRC meetings. The meeting of the General Council is the usual fall business meeting.

The ECAC Session will deal with proposals for the development of close working relationships among engineering colleges, high schools and junior colleges. Such relationships are becoming increasingly important, since they vitally influence the quantity and quality of students entering engineering colleges.

The main theme of the ECRC Session will be "Current Problems in University Research Relations." Primary attention will be given to:

1. Developments in contract relationships with the Federal Government;
2. Discussions of Basic Research in Engineering, particularly as may be related to the National Science Foundation Program;
3. General report on Washington research activities.

Report of the Engineering College Research Council, 1950–1951

The activities of the Research Council during the past twelve months have been set against the background of an unprecedented national need for the products of engineering and scientific talent. We are caught in the vise between greatly augmented needs of all kinds of engineering production and research—and decreasing numbers of men trained for these vital assignments. Though the real pressure from these factors is still ahead, in this environment the Research Council has already found new responsibilities and some of our greatest opportunities.

During the Fall, as the first phases of industrial and scientific mobilization were completed, the Research Council was represented at a series of conferences on the problems and responsibilities of educational institutions. These were climaxed in Washington in November, at the fall meetings of the American Society for Engineering Education, when the Research Council sponsored a panel discussion by principal federal officials concerned with research and development needs. Since that time we have continued active liaison with these federal agencies involved in the procurement of engineering research. In this work we have sought to supplement and guide the contacts of individual institutions—and to encourage them to seek the benefits of direct discussions.

We have recently completed the third volume in the continuing biennial series of "Review of Current Research," and this project, too, derives added urgency from its environment. With research and development needs outstripping our national capacity, it is important that we know what is being done, how, and where. We cannot now afford the luxury of duplication and repetition.

The 1951 "Review of Current Research" reflects the startling growth of engineering research in our member institutions. This year's book lists over 5200 individual research projects, the work of more than 11,500 faculty, graduate students, and research engineers. These projects are responsible for annual expenditures of $50.5 million in the 92 institutions now qualified for Engineering College Research Council membership. This is a growth of more than $15 million in a two-year period, and an increase of over 1000 projects and 1500 research workers.

Amendments to the By-Laws providing for the organization of regional sections of the Engineering College Research Council were approved during the past year. We hope that the new groups thus made possible may assist in the development of research activities in smaller engineering schools which do not qualify for Active Membership.

The Research Council's second major project during the current year has been the accomplishment of the Committee on Relations with Military Research Agencies, of which Dean A. F. Spilhaus is Chairman. Following the Washington meeting in November, this Committee was encouraged by the Research and Development Board to undertake an inventory of the resources for scientific and engineering research in American colleges and universities. Now for the first time, as a result of this work, we know the research potential of more than 500 educational institutions in these critical fields. We know the number of

faculty members and senior students qualified and available for research in the various fields of science and engineering at each school; we know the special areas in which these people are particularly interested and prepared to do research; and we know something of the kind of equipment with which they have to work.

It is far too early to estimate the effectiveness of this substantial project, but we are certain of its potential value to American higher education and we are assured of its importance to national defense.

The Committee has catalogued a substantial reserve of research potential in the smaller engineering and liberal arts institutions throughout this country which have thus far not been able to contribute their share of our research and development needs. Even in larger schools we have found an important reserve. I am confident that this project can make possible a more equitable distribution of research and development responsibilities to all colleges, can assure that colleges may maintain their scientific staffs by providing research opportunities in line with professional interests, and promises that scientific and technical education throughout the nation may be strengthened and enriched at a time when its product is most needed.

During the coming months the demands on educational institutions for research and development will be greatly augmented. It is important, in this period of increasing pressure, that all colleges and universities fulfill their responsibilities to the nation with seriousness and effectiveness. It is particularly necessary that, in so doing, they maintain their academic and fiscal integrity. We must obviously guard against poor research achievements; as our volume increases, and the pace of our tasks mounts, we must not permit standards to fall.

And we must maintain our positions as *educational* research organizations. For this is not merely a time when America needs the results of research and development. The vise which makes our present situation especially grave is that we need not only these new advances which can result from today's studies. We desperately need many, many more men qualified to do all kinds of research, and we as desperately need the fundamental information on which the developments of tomorrow will be based.

The tremendous amount of development and applied research required immediately by the national defense presents a challenge to all America's research facilities. In the colleges and universities these immediate demands should not displace the longer-range fundamental research which is traditionally our principal concern. Our task is to develop programs fulfilling, in as full measure as possible, both these needs.

In accepting our research and development obligations, we in colleges and universities must not submerge our roles as educational institutions. We must undertake our new tasks and, at the same time, we must exert every effort to make our teaching and research more effective —in terms of graduates still better equipped to contribute to the national welfare, and in terms of fundamental engineering science on which the nation may base its future progress.

GERALD A. ROSSELOT,
Vice President of the ASEE in Charge of the ECRC

Secretary's Report
1950–51

Despite the growing emphasis upon mobilization, the Society, during the past year, has endeavored to maintain a reasonable balance between the urgent problems of mobilization and the long-range activities associated with the improvement of engineering education. An effort has been made to work closely with administrators of engineering colleges; and to keep them informed of latest developments and to seek their counsel on national affairs affecting engineering Education.

The Administrative and Research Councils of the Society have carried most of the responsibility of the problems arising out of the mobilization program. Reports on their activities are given elsewhere in this issue of the JOURNAL; hence the following deals only with the general activities of the Society.

Engineering Manpower

Probably the foremost problem of the ASEE during the past year has been that of alerting government officials and the public as to the serious consequences of the impending engineering manpower shortage. The fiction of a large oversupply of engineering graduates, resulting from the GI avalanche of June, 1950, had gained widespread acceptance by government officials and the public. The total employment of the 1950 graduating class and the subsequent development of serious shortages of engineers, coupled with the abnormally low engineering student registrations, made it imperative that the ASEE take aggressive action.

In November, 1950, the Administrative Council of the ASEE held a meeting in Washington, D. C. dealing with the subject of the critical shortage of engineering manpower. Leading government officials were invited and a number of these appeared on the program. Also at the time of this meeting, the Coordinating Committee of Relations with the Federal Government arranged a meeting between members of their committee, the officers of the Society, and government officials in the Department of Labor, Department of Defense, Federal Security Agency and Department of Commerce. At this meeting, the problems associated with manpower shortages, the draft, and emergency educational programs were discussed. Following the meeting, the Department of Labor issued a public release which reversed their previous predictions and emphasized a growing shortage of engineering manpower.

In November, 1950, an article and editorial dealing with the critical shortage of engineering manpower appeared in the *New York Times*, based upon statistics supplied by Dean Hollister. The ASEE supplied over 160,000 reprint copies of this article and editorial to engineering colleges throughout the country for redistribution to high schools.

Subsequently, an Engineering Manpower Commission was formed by the Engineers' Joint Council to prepare a report on the military and industrial needs for engineering manpower and to correlate this with the supply of graduates from engineering colleges. It was also the function of the Manpower Commission to prepare specific recommendations for alleviating the shortage. The recommendations of this Commission and the testimony presented before congress have had a profound influence upon the thinking

of government officials and congressional people on the whole problem of engineering manpower. The Engineering Manpower Commission has prepared a program of recommendations, has issued numerous public releases, has presented testimony before congressional committees, and has embarked upon an extensive program to inform high school students and counselors of the potentialities in the engineering fields.

While the accomplishments of the ASEE and the Manpower Commission have resulted from the efforts of many persons, special credit must be accorded Dean Hollister for having crystalized the thinking on this problem and having taken the leadership in bringing the attention of the engineering societies to focus on the problem.

Improvement of Teaching

The Committee on Improvement of Teaching, under the chairmanship of Dr. Grinter, has made significant progress. The work of the Committee has been divided into three sub-committees under the chairmanship of Dean H. P. Hammond, Dr. J. F. Calvert and Dr. A. P. Colburn. At the request of Dr. Grinter, a number of engineering colleges have appointed special committees to study methods of effecting the improvement of engineering education and also to supply information to the Society's committee. An interesting and illuminating report will be forthcoming from this committee in the near future.

ASEE Commission on Engineering Education to Japan

At the request of the supreme commander for Allied Powers, the ASEE, in cooperation with the Unitarian Service Committee, has organized a commission of fifteen engineering educators to visit Japan. The commission will consult with the Ministry of Education of the Japanese government and officials and educators of Japanese universities. Harold L. Hazen, Head of the Department of Electrical Engineering at the Massachusetts Institute of Technology, will serve as chairman. The Unitarian Service Committee was appointed by SCAP to handle all U. S. Government administrative relations. The commission was organized by H. P. Hammond, Dean of Engineering, Pennsylvania State College. The commission members include: C. W. Beese, A. B. Bronwell, W. R. Chedsey, A. G. Christie, A. B. G. Dietz, B. F. Dodge, H. L. Dodge, R. B. Finch, H. L. Hazen, A. L. Miller, J. A. Sauer, E. W. Steel, H. B. Walker, F. L. Wilkinson and R. S. Williams.

Educational Testing Service

The ASEE Committee on Selection and Guidance, under the chairmanship of Professor Russell Beatty, has worked closely with the Educational Testing Service on the construction and publication of new Pre-Engineering Inventory tests. They have proven to be reasonably predictive of scholastic success in engineering. The Selection and Guidance Committee has contacted the individual examining officers in each of the accredited engineering colleges of the country, as well as the engineering deans, in order to familiarize them with the tests available and to encourage their adoption.

Teaching Aids Committee

The Committee on Teaching Aids of the ASEE, with Professor Carl Muhlenbruch as chairman, has successfully completed a fund-raising campaign to finance the program of evaluation of teaching aids. The work of the Committee, during the next year, will enter the second phase, that of the evaluation of teaching aids available for engineering instruction and the publication of a bulletin listing recommended teaching aids. Reviewing committees have been appointed in five curricular areas. An exhibit of teaching aids is being planned for the Annual Meeting at Michigan State College.

Unity of the Profession

The committee on Unity of the Profession, organized by the Engineers' Joint Council, has submitted its report. The report presents four alternate proposals for an organization to unify the engineering profession. These proposals have been submitted to the participating engineering societies for expressions of opinion of the society officers and members. After the opinions have been received, the Committee will resume its meetings in an effort to draw up a plan of organization which shows the greatest promise of successful adoption. The ASEE representative, Dean Thorndike Saville, has actively participated in the Committee deliberations and has served on the planning committee which drew up the proposals.

Mid-Year Meetings

The ECAC and ECRC held meetings in November in Washington, D. C. The Administrative Council's program dealt with the engineering manpower shortage and included on its panel of speakers officials in various government agencies. The ECRC meeting was devoted to a discussion of research facilities and potential, with emphasis upon the problems associated with defense research projects. These meetings were attended by approximately 300 administrators and faculty members of engineering colleges.

The Division of Relationships with Industry held a highly successful mid-year meeting in Cleveland, Ohio on January 20, 1951. The theme dealt with industry's requirements for engineering manpower, the draft, and the mobilization program. This meeting was attended by 200 representatives from industry and colleges.

The Drawing Division held its annual mid-year meeting on January 18–20 at Texas A. & M. College. Approximately 90 persons attended.

The cooperative Education Division held a meeting of representatives of fourteen schools offering cooperative engineering programs at the University of Florida on June 9–10, 1951. The meeting dealt largely with the type of training programs which industry should provide for cooperative engineering students. Proposals and problems of cooperative relations in civil service were also discussed.

Committee on International Relations

The Committee on International Relations, under the Administrative Council, has planned a meeting of international educators in conjunction with the Annual Meeting of the ASEE. Invitations were sent by Dean Woolrich, chairman of the Committee, to engineering educators in countries of the world outside of the Iron Curtain. It is becoming increasingly apparent that the ASEE can serve as a constructive influence in helping the nations of the world to get a deeper understanding of what constitutes engineering education and thereby improve their own educational systems. The Society can also serve as an international forum for engineering educators, thereby aiding in the dissemination of knowledge and fostering goodwill among engineering educators in many lands.

Renewal of George Westinghouse Award

The Westinghouse Educational Foundation has renewed its agreement with the ASEE providing for the granting of an annual George Westinghouse Award for another period of five years. This award consists of $1,000 and a certificate, presented to a recipient selected by the George Westinghouse Award Committee of the ASEE. The Committee has set an age limit of 45 for this award in order to serve as an encouragement for younger teachers.

Summer Schools

Three summer schools have been formally approved for ASEE sponsorship by the Executive Board. These are sponsored by the Humanistic-Social Division, the Engineering Drawing Division, and the Mechanical Engineering Division (Thermodynamics).

Cooperation with Other Organizations

The ASEE continued its active cooperation with other educational and engineering societies. A contribution was made to the Engineers' Council for Professional Development to assist it in instituting a program of professional training for young graduate engineers in industry. This program has been supported by a number of other engineering societies and will probably be launched in 1951–52. Its purpose is to encourage industry and universities to set up educational programs for young engineers in order to enable them to continue their professional growth in the years immediately after graduation.

Representatives of the ASEE have also taken an active part in the affairs of the Engineers' Joint Council, the American Council on Education, the American Standards Association, and other organizations.

Atomic Energy Conferences

A highly successful enterprise during the past year has been the conferences of the regional Atomic Energy Committees, organized under the chairmanship of Dr. Armsby. These committees have established an effective working liaison between the colleges and the atomic energy laboratories, providing for a flow of technical information on atomic energy to the college faculties. A series of papers on atomic energy, arising out of the conferences, has been published in the Journal and others are to follow.

Society Finances

Inflationary times are always difficult times for engineering societies and the ASEE is no exception. During the past four years, prices have almost doubled, but the ASEE has continued to operate with a balanced budget, despite the fact that its dues are approximately one third of those of other engineering societies. This has been made possible only by conducting a vigorous membership campaign, thereby increasing the Society income, and by keeping overhead costs to a minimum. Over 3500 new members have been added to the membership rolls in the past four years. It appears quite probable that the Society is approaching a saturation point in its membership and that there may even be some decline. This appears evident from the fact that the rapidly declining college enrollments will inevitably be coupled with a decline in the number of college teachers. It also appears doubtful at the present time that the general price level will remain stationary. The Society has been notified of an eight per cent increase in the cost of printing of the JOURNAL, an item which consumes over one-half of the total Society income, and other Society expenses are increasing proportionately. It therefore appears that more stringent circumstances lie ahead. The Executive Board is keenly aware of the financial problem and is making a serious effort to maintain a balance between income and expense.

Officers Activities

A final word of commendation is in order for the energetic and constructive activities of your officers and particularly your President. During the past year, President Dawson personally visited numerous Sections and Division meetings and attended most of the intersociety engineering meetings. He has exerted a constructive and beneficial influence wherever problems arose which impinged upon engineering education.

Respectfully submitted,

ARTHUR BRONWELL
Secretary

TIMELY TIPS

TIMELY TIPS *is a new section in the Journal devoted to unique ways of teaching difficult concepts so that they can be easily grasped by students. Contributions to this section should constitute an improvement over current textbook presentations. They should not exceed two Journal pages in length (including illustrations). If you have novel, short-cut methods of making difficult concepts seem simple, your colleagues will be glad to see them in the Journal. Send contributions to the Editor, Professor A. B. Bronwell, Northwestern University, Evanston, Illinois.*

Four Methods or One in Teaching Deflections?

By M. W. JACKSON

Assistant Professor of Civil Engineering,
University of Colorado

The principles of Virtual Work, Dummy Load, Conjugate Beam, and Area Moments for the calculation of deflections are too often considered in teaching as if they were entirely different. The names are more confusing than are the methods. If the interrelationships between them were better understood, it would perhaps simplify the study of deflections and rotations in courses in Strength of Materials and Indeterminate Structures. The following is a simple demonstration for comparing all four methods.

The beam shown in Fig. 1(a) is considered perfectly rigid except for the portion dx. It is desired to find the deflection of point C caused by the elastic deformation of the differential portion of the beam, dx. The usual assumptions in the solution of engineering structures are applied, that deflections are small, that the difference between the angle of rotation, the sine, and the tangent of the angle is negligible, and that the assumptions of the flexure formula apply.

There is an internal or resisting moment, M, at the section dx due to the applied loads, P_1, P_2, and P_3, which is equal to the applied moment. It has been shown prior to the study of this topic in the usual course in elementary strength of materials that $\frac{M\ dx}{E\ I} = \theta$. The angle, θ, as shown in Fig. 2, is the angle of rotation of adjacent faces of a differential element, dx, of a beam over which M is assumed constant. The assumed beam (rigid except for the elastic section dx) will deflect due to rotation of the faces of the element into the position AEB as shown in Fig. 1(b). Then,

$$\alpha = \tan \alpha = \theta \frac{\overline{AD}}{L}.$$

$$\Delta_c = \alpha \overline{CB} - \theta\, \overline{CD} = \theta \frac{\overline{AD}}{L} \overline{CB} - \theta\, \overline{CD}.$$

Simplifying,

$$\Delta_c = \theta \left(\frac{\overline{AD}}{L} \overline{CB} - \overline{CD} \right). \qquad (1)$$

The relation in equation (1) is purely geometric and will be the same no matter how the angular deformation θ is produced. Study of the quantity in the parenthesis in equation (1) is the point

of departure for obtaining the equations for the different methods of calculating deflections.

If a 1 pound load is applied at C as shown in Fig. 1(c), the reaction at A is $\frac{\overline{CB}}{L}$, and the moment at D due to this 1 pound load is $m = \frac{\overline{CB}}{L}\overline{AD} - \overline{CD}$. In other words, m is the bending moment at D due to a 1 pound load applied to the beam at C. Substituting m in equation (1), $\Delta_c = \theta\, m$. The value of m is an arbitrary value independent of the actual deformation of the beam or the actual loading of the beam.

The actual loads on the beam, P_1, P_2, and P_3, produce a bending moment, M, at section D, with a corresponding angle change θ between the parallel faces of the element equal to $\frac{M\,dx}{E\,I}$. Therefore the deflection at C due to the actual loads on the beam (considering

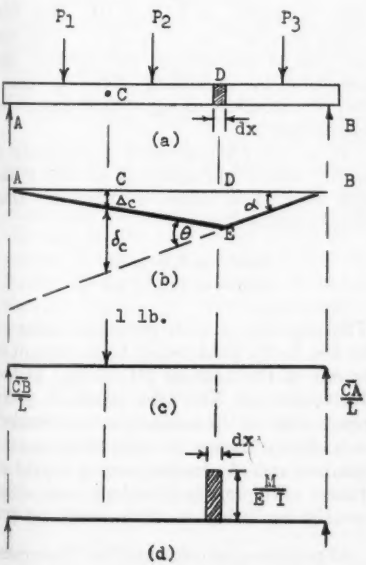

FIG. 1.

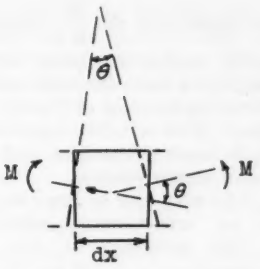

FIG. 2.

only the dx portion elastic) is $\Delta_c = \frac{M\,dx}{E\,I}\,m$. If the beam is now considered elastic throughout its entire length, the effect of the bending moment on each differential element will produce an angular deformation of that element and a corresponding deflection at C. Summing the deflections produced by each element, $\Delta_c = \int \frac{M\,m\,dx}{E\,I}$. This equation will be recognized as the basis for virtual work, the dummy unit load method, Maxwell-Mohr method, elastic energy, and others likewise of different names but utilizing the same final equation.

Equation (1) has another interpretation. As shown in Fig. 1(d), a load equal to $\frac{M\,dx}{E\,I}$ is applied to the beam at D. This load, or *area*, produces a rotation θ of the adjacent faces of the element, dx, since $\theta = \frac{M\,dx}{E\,I}$. The reaction at B of the beam thus loaded is, $\theta\,\frac{\overline{AD}}{L}$. The bending moment about C (considering the right hand portion of the beam) is $\theta\,\frac{\overline{AD}}{L}\,\overline{CB} - \theta\,\overline{CD}$, which is equal to Δ_c in equation (1). Therefore the deflection at C due to $\frac{M\,dx}{E\,I}$ applied as a load to the beam at D is equal to the bending moment at C due to that load on the beam. If then the entire beam is con-

sidered elastic and the $\frac{M}{E\,I}$ diagram for the actual loading is applied to the entire beam as a load, the deflection at C is the bending moment at C produced by this load. This will be recognized as a conjugate beam proposition and as the method of elastic weights.

Fig. 1(b) may also be used to demonstrate an area-moment relationship. From the geometry of the figure, $\delta_e = \theta\,\overline{CD}$. Since $\theta = \frac{M\,dx}{E\,I}$, due to the loads on the beam, $\delta_e = \frac{M\,dx}{E\,I}\,\overline{CD}$. Consequently it may be said that the deflection of C from a tangent through D is equal to the moment about C of the area $\frac{M\,dx}{E\,I}$ applied at D. It may be seen that angle changes between A and C, and between D and B, do not affect δ_e. Considering the effect of all of the angle changes between C and D, the angle θ for each differential element is produced by the moment on that element due to the applied loads. Therefore, it may be said that the deflection of C from a tangent through D is equal to the moment about C of the area of the $\frac{M}{E\,I}$ diagram between C and D. This is one of the area-moment principles.

Some steps desirable for a rigorous proof of any of the above propositions have been omitted here to save space, but the main parts have been outlined. Similar procedures may be used to establish the relationships for rotations for any of the above systems.

Big Numbers and Little Numbers

By R. E. NEWTON[1] AND H. R. GRUMMANN[2]

30,000,000 is a big number and 0.0000065 is a little one, yet both are typical magnitudes of concern to the engineering student and practicing engineer alike. Faced with the stark necessity of dealing with such numbers within the confines of finite sheets of paper and still not loosing track of the decimal point, engineers have adopted a number of strategems. Electrical engineering is replete with examples of one of these—thus we have the *meg*ohm, the *kilo*watt, the *milli*volt, the *micro*ampere, etc. Another device, found frequently in tables and graphs, is the heading: $(\times 10^{-6})$. (For the tyro a factor of 10^{12} is at stake here!) This latter device has real merit when the user takes the trouble to be explicit. Employing it thus, we may write our "big number" as 3.0×10^{7} and our "little number" as 6.5×10^{-6}. This has obvious advantages on two counts: the necessity for counting zeros is gone, and the number of significant figures is unambiguous.

It is our purpose here to indicate a highly useful abridgement of this notation which also makes it compact. One simply writes

$$3.0\backslash^{7} = 3.0 \times 10^{7},$$
$$6.5\backslash^{-6} = 6.5 \times 10^{-6}.$$

The inventor of this notation seems to be Dr. L. B. Tuckerman,[3] who taught it to one of the authors (H. R. G.) at the University of Nebraska over 35 years ago. Both of the authors have presented it to many classes in engineering mathematics and mechanics over a period of years. Frequently this has been done merely by using it while working out

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[3] Until his recent retirement Dr. Tuckerman was associated for many years with the National Bureau of Standards.

illustrative examples at the blackboard (the notation has, of course, always been explained briefly at the time of initial use). We have found that students quickly comprehend this abbreviation and many adopt it for their own work. It has particular advantages in many slide rule operations. We consider a single example which is amply endowed with opportunities for decimal point error. In finding the tip deflection of a steel cantilever beam ($I = 82.5$ in.^{4}) of 30 foot span under a tip load of 1250 lb., one is led to the computation

$$\delta = \frac{PL^3}{3EI} = \frac{(1.25\backslash 3)(3.6\backslash 2)^3}{(3)(3\backslash 7)(8.25\backslash 1)} = 0.785\backslash 1$$
$$= 7.85 \text{ in.}$$

The location of the decimal point in the first form of the result is easily fixed by a rough mental calculation. The determination of the exponent of 10 is, of course, a simple application of the laws of exponents. The use of the convention is certainly no guarantee against decimal point errors in such computations, but experience shows that they are greatly reduced thereby.

Clearly the number of examples of the usefulness of the method could be multiplied *ad nauseam*, but no purpose would be served by this. The advantages, we believe, are apparent. We strongly urge its presentation to technical students, early in their academic careers.

College Notes

Massachusetts Institute of Technology and **Harvard University** today announced plans for a joint five-year program aimed at increasing the number of broadly trained science and mathematics teachers available to secondary schools. Under the new Harvard-M.I.T. curriculum, beginning next September, young men and women will be trained for science and mathematics teaching in high schools and junior colleges. Their course will lead to the degrees of Bachelor of Science in General Science at M.I.T. and Master of Arts in Teaching at nearby Harvard University. The undergraduate phase of the project is largely at M.I.T., although some Harvard courses may be taken as early as the third year. Thereafter, students will take courses at both institutions and draw on the educational resources of both. During the fifth year, students will teach part-time at local high schools, under the direction of the Faculty of the Harvard School of Education.

Seventy faculty members, largely from the Southern universities, are spending this summer on research projects in the **Oak Ridge** facilities of the **Atomic Energy Commission.** They are in Oak Ridge under the auspices of the Research Participation Program, a joint activity of the Oak Ridge Institute of Nuclear Studies and the Oak Ridge National Laboratory. The great majority will work in the extensive research facilities of the Oak Ridge National Laboratory, but others will be on duty with the Institute Medical Division and the University of Tennessee-AEC Agricultural Research Program. In addition to the 70 individuals who will be in Oak Ridge for the entire summer or longer, 96 participants will attend the three one-month courses in radioisotope techniques offered by the Special Training Division of the Institute this summer. An additional twenty will attend the Division's course in autoradiography, and several hundred are expected for the annual Oak Ridge Summer Symposium, devoted this year to "The Role of Engineering in Nuclear Energy Development." It will be held from August 27 to September 7.

New Members

ACTON, FRANK, J., Associate Professor of Mechanical Engineering, Tri-State College, Angola, Ind. J. G. Radcliffe, J. C. Humphries.

AHLBERG, CLARK D., Assistant Dean, Administrative Engineering, Syracuse University, Syracuse, N. Y. B. H. Norem, R. A. Galbraith.

AKESSON, NORMAN B., Lecturer, Agricultural Engineering, University of California, Davis, Calif. S. M. Henderson, L. Bamir.

ARTHUR, GEORGE R., Instructor in Electrical Engineering, Yale University, New Haven, Conn. A. G. Conrad, J. G. Clarke.

ATKINS, JACK W., Instructor in Engineering, Weber College, Ogden, Utah. M. L. Stevenson, J. E. Christiansen.

BAEUMLER, HOWARD WILLIAM, Instructor in Mathematics, University of Buffalo, Buffalo, N. Y. H. M. Gehman, R. E. Shaffer.

BARTHOLOMAEI, NATHANIEL T., Instructor in Mechanical Engineering, Clarkson College of Technology, Potsdam, N. Y. E. McHugh, M. G. Mochel.

BENNETT, CARSON W., Librarian, Rose Polytechnic Institute, Terre Haute, Indiana. C. E. Kircher, Jr., R. K. Strong.

BLANCHARD, FLETCHER, A., JR., Instructor in Electrical Engineering, University of New Hampshire, Durham, N. H. E. H. Stolworthy, O. T. Zimmerman.

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BLUMENTHAL, IRWIN S., Instructor in Electrical Engineering, Yale University, New Haven, Conn. J. G. Clarke, A. G. Conrad.

BOUGHTON, ROLAND W., Chief, AF Academy Curriculum Planning Group, United States Air Force Academy (proposed), Bolling Air Force Base, Washington 25, D. C. C. W. Muhlenbruch, E. F. Obert.

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BUFFA, ELWOOD S., Assistant Professor of Mechanical Engineering, University of Illinois, Urbana, Ill. E. Laitala, C. H. Cosberg.

BUNNELLE, PHILIP R., Lecturer, Agricultural Engineering, University of California, Davis, Calif. S. M. Henderson, R. Bainer.

BURCHFIELD, GEORGE E., Instructor in Engineering Shop, General Motors Institute, Flint, Mich. H. M. Dent, C. L. Fanning.

BURKE, DALE H., Tool Engineer, Production Engineering, Champion Spark Plug Co., Toledo, Ohio. W. F. Rohr, W. G. Rohr.

BYERS, EARLE C., Instructor in Shop Practice, Kansas State College, Manhattan, Kans. G. C. Timmons, G. A. Sellers.

CEBULA, RICHARD S., Instructor in Civil Engineering, St. Martin's College, Olympia, Wash. F. Kerekes, S. H. Fuller.

CHEDSEY, WM. R., Professor of Mining Engineering, University of Illinois, Urbana, Ill. H. L. Walker, F. M. Dawson.

CHERRY, LLOYD B., Professor and Head, Electrical Engineering Department, Lamar State College of Technology, Beaumont, Texas. E. R. Stapley, A. Naeter.

CLARK, MARLYN E., Instructor in Mechanics, University of Illinois, Urbana, Ill. F. B. Seely, J. O. Smith.

CLARK, WILLIAM E., Instructor in Mechanical Engineering, University of New Hampshire, Durham, N. H. E. H. Stolworthy, E. T. Donovan.

COWLES, HAROLD A., Instructor in General Engineering, Iowa State College, Ames, Iowa. S. J. Chamberlin, M. B. Richardson.

CRAWFORD, JOHN H., Dean of Engineering, Merrimack College, Andover, Mass. S. Morehouse, J. J. Gallen.

CURRAN, BROTHER HENRY, Instructor in Engineering, St. Edward's University, Austin, Texas. B. E. Short, B. F. Treat.

DABNEY, WALTER H., Associate Professor of Civil Engineering, Tennessee A. & I. State College, Nashville, Tenn. D. E. Howard, E. R. Welch.

DANIELS, TED E., Project Engineer, Wind Division, Stewart-Warner Corporation, Indianapolis, Ind. W. W. Turner, C. P. Buck.

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DE NEUFVILLE, ALBERT, Instructor in Mechanics, Lehigh University, Bethlehem, Pa. F. P. Beer, P. F. Miller.

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DIMASI, LOUIS A., Director, Penn Technical Institute, Pittsburgh, Pa. K. L. Holderman, N. P. Bosted.

DUCODY, MICHAEL M., Instructor in Mechanical Engineering, University of Detroit, Detroit, Mich. H. Gudebski, C. G. Duncombe.

DURHAM, DWIGHT W., Assistant Supervisor of College Relations Group, Personnel Div., E. I. duPont de Nemours Co., Wilmington, Dela. T. H. Chilton, G. O. Andrews.

DUTTON, BENSON L., Director of Engineering, Tennessee A. & I. College, Nashville, Tenn. L. K. Downing, A. K. Richmond.

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FITZGIBBONS, JAMES J., Instructor in Electrical Dept., State University of New York, Buffalo, N. Y. P. F. Goliber, R. W. Marsh.

FLARITY, EARL C., Coordinator, Technical Training Div., Ind. Edu. Dept., Chrysler Corp., Detroit, Mich. D. C. Hunt, O. B. Norem.

FORNOFF, FRANK J., Associate Professor of Chemistry, Lehigh University, Bethlehem, Pa. H. A. Neville, P. F. Miller.

FRAZER, JOHN R., Assistant Professor of Industrial Engineering, Iowa State College, Ames, Iowa. S. J. Chamberlin, M. B. Richardson.

FREY, AUSTIN R., Chairman, Physics, U. S. Naval Postgraduate School, Annapolis, Md. F. M. Dawson, A. B. Bronwell.

GOODMAN, LOUIS J., Assistant Professor of Civil Engineering, Ohio State University, Columbus, Ohio. F. M. Mallett, K. W. Cosens.

GOODWIN, ERNEST B., Assistant Professor of Electrical Engineering, University of Rhode Island, Kingston, R. I. W. B. Hall, C. B. Clarke.

GOODWIN, WILLIAM A., Instructor in Civil Engineering, University of Kentucky, Lexington, Ky. F. J. Cheek, Jr., D. K. Blythe.

GREER, ROBERT W., Instructor in Electrical Engineering, Milwaukee School of Engineering, Milwaukee, Wis. R. J. Ungrodt, F. J. Van Zeeland.

GREIBER, CLARENCE L., State Director of Vocational and Adult Education, State Board of Voc. and Adult Education, Madison, Wis. E. C. Koerper, F. T. Agthe.

GUILD, LAWRENCE R., Professor and Head, Depts. of Management and Industrial Engineering, University of Southern California, Los Angeles, California. R. E. Vivian, L. R. Schruben.

HAAS, WILBUR M., Instructor in Civil Engineering, University of Wisconsin, Madison, Wis. E. C. Wagner, H. A. Kallsen.

HAASE, HAROLD F., Associate Professor of Mechanical Engineering, Marquette University, Milwaukee, Wis. W. D. Bliss, J. E. Matar.

HALL, KEITH W., Assistant Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. E. P. Vincent, F. Schwartz.

HOILMAN, CHARLES W., Associate Professor of Electrical Engineering, University of Vermont, Burlington, Vt. R. P. Mosher, E. R. McKee.

HOLDREDGE, EDWIN S., Associate Professor of Mechanical Engineering, A. & M. College of Texas, College Station, Texas. W. I. Truettner, R. M. Wingren.

HOSMER, W. T., Assistant Professor of Civil Engineering, Iowa State College, Ames, Iowa. R. Winfrey, L. O. Stewart.

HOWELL, AVANELLE M., Engineering Librarian, Alabama Polytechnic Institute, Auburn, Ala. J. E. Hannum, C. R. Hixon.

HUFFMAN, JOHN R., Assistant Professor of Industrial Engineering, University of Southern California, Los Angeles, Calif. R. E. Vivian, L. A. Schruben.

HULSBOS, C. L., Assistant Professor of Civil Engineering, Iowa State College, Ames, Iowa. R. Winfrey, L. O. Stewart.

IBATA, RALPH M., Assistant Professor of Electrical Engineering, University of Nebraska, Lincoln, Neb. E. J. Ballard, O. E. Edison.

INVEISS, JANIS H., Assistant Professor of Mechanics, Milwaukee School of Engineering, Milwaukee, Wis. E. Petty, S. A. Eng.

JODREY, ROBERT N., Instructor in Mechanical Engineering, University of New Hampshire, N. H. E. T. Donovan, E. H. Stolworthy.

JONES, THOMAS R., Chief Librarian, Engigineering School, Fort Belvoir, Va. R. B. Allen, P. A. Wedding.

KANE, ENEAS D., Associate Professor of Engineering, University of California, Berkeley, Calif. A. S. Levans, M. P. O'Brien.

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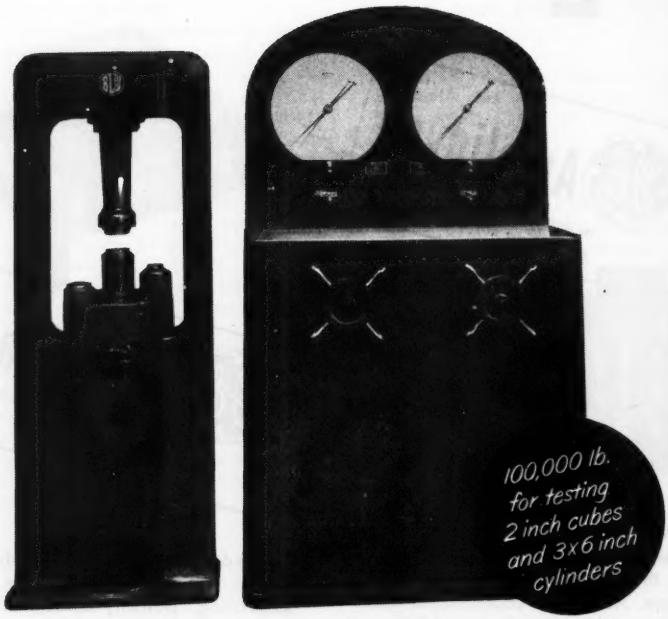

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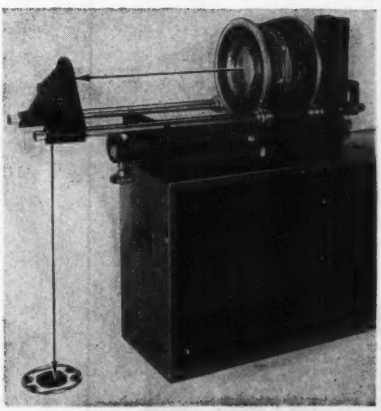

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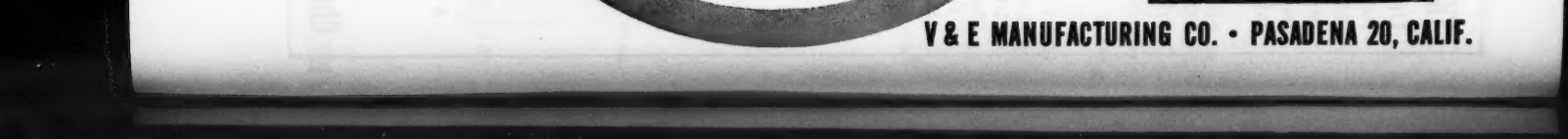

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